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PREFACE

The International Library of Technology is the outgrowth of a large and increasing demand that has arisen for the Reference Libraries of the International Correspondence Schools on the part of those who are not students of the Schools. As the volumes composing this Library are all printed from the same plates used in printing the Reference Libraries above mentioned, a few words are necessary regarding the scope and purpose of the instruction imparted to the students of—and the class of students taught by—these Schools, in order to afford a clear understanding of their salient and unique features.

The only requirement for admission to any of the courses offered by the International Correspondence Schools, is that the applicant shall be able to read the English language and to write it sufficiently well to make his written answers to the questions asked him intelligible. Each course is complete in itself, and no textbooks are required other than those prepared by the Schools for the particular course selected. The students themselves are from every class, trade, and profession and from every country; they are, almost without exception, busily engaged in some vocation, and can spare but little time for study, and that usually outside of their regular working hours. The information desired is such as can be immediately applied in practice, so that the student may be enabled to exchange his present vocation for a more congenial one, or to rise to a higher level in the one he now pursues. Furthermore, he wishes to obtain a good working knowledge of the subjects treated in the shortest time and in the most direct manner possible.

In meeting these requirements, we have produced a set of books that in many respects, and particularly in the general plan followed, are absolutely unique. In the majority of subjects treated the knowledge of mathematics required is limited to the simplest principles of arithmetic and mensuration, and in no case is any greater knowledge of mathematics needed than the simplest elementary principles of algebra, geometry, and trigonometry, with a thorough, practical acquaintance with the use of the logarithmic table. To effect this result, derivations of rules and formulas are omitted, but thorough and complete instructions are given regarding how, when, and under what circumstances any particular rule, formula, or process should be applied; and whenever possible one or more examples, such as would be likely to arise in actual practice—together with their solutions—are given to illustrate and explain its application.

In preparing these textbooks, it has been our constant endeavor to view the matter from the student's standpoint, and to try and anticipate everything that would cause him trouble. The utmost pains have been taken to avoid and correct any and all ambiguous expressions—both those due to faulty rhetoric and those due to insufficiency of statement or explanation. As the best way to make a statement, explanation, or description clear is to give a picture or a diagram in connection with it, illustrations have been used almost without limit. The illustrations have in all cases been adapted to the requirements of the text, and projections and sections or outline, partially shaded, or full-shaded perspectives have been used, according to which will best produce the desired results. Half-tones have been used rather sparingly, except in those cases where the general effect is desired rather than the actual details.

It is obvious that books prepared along the lines mentioned must not only be clear and concise beyond anything heretofore attempted, but they must also possess unequaled value for reference purposes. They not only give the maximum of information in a minimum space, but this information is so ingeniously arranged and correlated, and the indexes are so full and complete, that it can at once be made available to the reader. The numerous examples and explanatory remarks, together with the absence of long demonstrations and abstruse mathematical calculations, are of great assistance in helping one to select the proper formula, method, or process and in teaching him how and when it should be used.

Four of the volumes composing this library are devoted to the subject of architectural and decorative design. Special attention has been given to the arrangement of the subjects in a naturally consecutive order, so that the fundamental principles underlying the advanced subjects may be thoroughly understood before the broader and freer subjects depending on the taste of each individual are considered. This volume, the first of the series, is devoted to the subjects of Geometrical, Freehand, Perspective, and Architectural Drawing, which are treated purely from the mechanical standpoint of making accurate scale sketches and working drawings according to accepted practice. The mathematical precision required to make an accurate drawing for any purpose, is herein treated on the principle that the freest and most broadly artistic rendering is at all times built on a skeleton, or framework, of accurate proportions, and the student must understand the mathematical principles by which these proportions can be determined before he can take up the subject of rendering in any medium the light and shade values that go to make the drawing pictorial.

The method of numbering the pages, cuts, articles, etc. is such that each subject or part is complete in itself; hence, to make the index intelligible, it was necessary to give each subject or part a number. This number is placed at the top of each page, on the headline, opposite the page number; and to distinguish it from the page number it is preceded by the printer's section mark (§). Consequently, a reference such as § 16, page 26, will be readily found by looking along the inside edges of the headlines until § 16 is found, and then through § 16 until page 26 is found.

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GEOMETRICAL DRAWING

DEFINITIONS

1. A **drawing** is a representation of an object on a plane surface by means of simple lines or a combination of lines and shades. When done by the free hand only, it is called **freehand drawing;** when instruments are used, so that exactness may be obtained, it is called **instrumental,** or **mechanical, drawing.**

2. In **geometrical drawing,** certain expressions are used to represent familiar objects that are not always identical with the terms used in every-day conversation, and terms with which we are familiar ordinarily assume a new and more limited meaning when considered strictly from a geometrical standpoint. For instance, one has a fairly satisfactory idea of a straight line, but, geometrically, a **straight line** is considered as one that has the same direction at every point, as the slightest deviation from one point to another would prevent the line from being straight.

A **curved line** is one that changes its direction by gradual or easy variations at every point.

Any plane (flat) closed figure made up entirely of straight lines is called a **polygon;** see Fig. 8.

A **circle** is a figure bounded by a curved line, every point of which is equidistant from a point within called the **center,** while the curved line bounding the figure is called the **circumference.** Thus, Fig. 1 is a circle because every point of the curved line bounding it, such as a, b, c, etc., is equidistant from the center o. Any line drawn through a

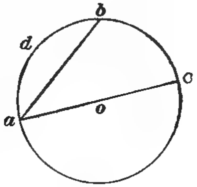

Fig. 1

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circle meeting its circumference in two places, as *a*, *b*, is called a **chord,** and the part of the circumference between the two ends of a chord, as *a d b*, is called an **arc.** Any chord passing through the center of a circle, as *a c*, is called the **diameter.** The distance *o c* or *o a* is equal to half the diameter and is called the **radius.**

3. In geometrical drawing, circles are drawn with compasses, as explained later. Such expressions as "describe a circle with a radius of 1 inch" or "describe an arc with a radius of 1 inch" mean that the student is to draw with the compasses a circle or an arc whose radius is 1 inch. Any polygon drawn within the circumference of a circle so that all its corners touch that circumference, is said to be **inscribed** within the circle, as in Fig. 2, where the square *a b c d* is inscribed within the circle. Any polygon drawn outside of a circle so that all its sides touch the circumference, as shown in Fig. 3, is said to be **circumscribed** about the circle. In the same manner, a circle can be inscribed in, as in Fig. 3, or circumscribed about any regular figure, as in Fig. 2.

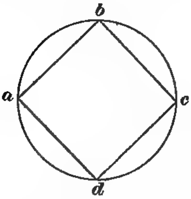


FIG. 2

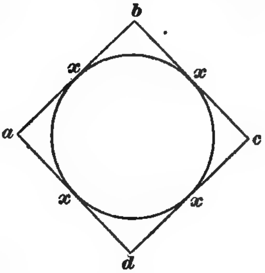


FIG. 3

When a straight line just touches the circumference of a circle without cutting into it as a chord would do, the line is said to be **tangent** to the circumference at that point, as at *x* in Fig. 3.

FIG. 4

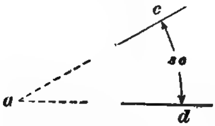


FIG. 5

When two straight lines are equidistant at every point from each other, they are said to be **parallel,** as in Fig. 4; but where they would meet if prolonged, as at *a*, Fig. 5, they are said to be at an **angle** with each other, and this angle is measured by the arc of a circle struck between them, as at $c\,d$, with its center at the point of intersection a. This point of intersection is called the **vertex** of the angle.

4. For the purpose of measuring angles uniformly, the circumference of a circle is divided into 360 equal parts called **degrees,** as in Fig. 6, and the number of these parts included between any two straight lines, drawn from the center of the circle, measures the number of degrees of that angle, as at $a\,b$. It makes no difference what the size of the circle is that is used to measure the angle, since in the larger circle the degree marks would be farther apart and the same number would be included between the diverging straight lines that measure the angle as shown by the arc $c\,d$. An angle of 90° representing one-quarter of the circumference of a circle, as at e, Fig. 6, is called a **right angle.** One having less than 90° is called an **acute angle,** and one having more than 90° an **obtuse angle.** A line making an angle of 90° with another line is said to be **perpendicular** to that line. All level lines or lines at right angles to vertical or plumb-lines are called **horizontal lines.**

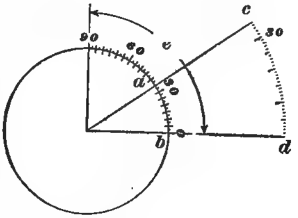


FIG. 6

5. So far nothing has been considered except lines and their relations to each other, but a space bounded by straight or curved lines is called a **surface.** Thus, in the circle, Fig. 1, its circumference is simply a line, whereas the space enclosed by the circumference is a surface. Figures assume different names according to their forms. One with three sides is termed a **triangle,** Fig. 7; it may be a right triangle, Fig. 7 (*a*), an acute triangle, Fig. 7 (*b*), or an obtuse triangle, Fig. 7 (*c*), according to its principal angle. Where all three angles and all three sides are equal, it is called an **equilateral triangle,** Fig. 7 (*d*).

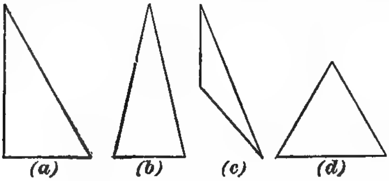

(a) (b) (c) (d)

FIG. 7

A figure having four sides is called a **quadrilateral,** Fig. 8 (*a*), (*b*), and (*c*). Where each pair of opposite sides is parallel, the figure is called a **parallelogram,** Fig. 8 (*a*); where the sides are parallel and the angles are right angles, it is called a **rectangle,** Fig. 8 (*b*); a rectangle whose sides are equal is called a **square,** Fig. 8 (*c*). Other figures take the names of **pentagon,** as Fig. 8 (*d*), **hexagon,** Fig. 8 (*e*), **octagon,** Fig. 8 (*f*), etc., according to whether they have five, six, or eight angles and sides, respectively. Figures with more than three sides are generally termed **polygons.** Thus pentagons, octagons, etc. are also polygons. A polygon can have any number of sides. A polygon is said to be regular when all of its sides and angles are equal.

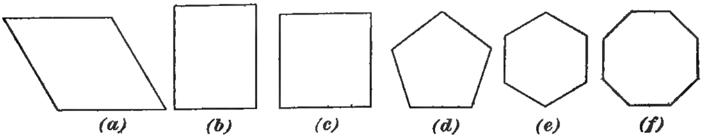


FIG. 8

6. Surfaces have only two dimensions, length and breadth, but where an object has a third dimension—thickness—it is called a **solid.** Thus, in Fig. 9, we have a solid whose length *a*, breadth *b*, and thickness *c* are all equal, and whose three visible sides are squares; this figure is called a **cube.**

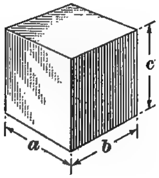


FIG. 9

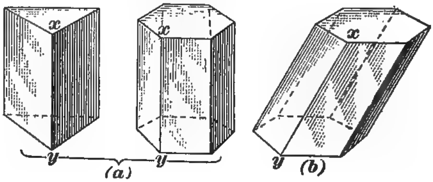


FIG. 10

Any figure having a triangle, square, hexagon, or other regular surface for its base, and parallelograms for its sides, as in Fig. 10, is called a **prism.** It is a *right prism* if the parallelograms forming its sides are rectangles, Fig. 10 (*a*), and an *oblique prism* if the parallelograms are other than rectangles, Fig. 10 (*b*). A figure having a circle for a base, and an equal circle for its top with an unbroken surface between, as in Fig. 11, is called a **cylinder.** A figure having any regular polygon for a base and triangles meeting in a point for its sides, as in Fig. 12, is called a **pyramid;** the point where its sides meet is called the **apex.** A figure having a circle for a base and its sides meeting in an apex, as in Fig. 13, is called a **cone.** An imaginary line from the center of the base to the apex or center of the top of any pyramid, cone, prism, or cylinder is called the **axis.**

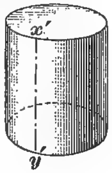


FIG. 11

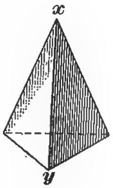


FIG. 12

As neither a cylinder nor a cone has any projecting angles on its sides to mark a line from its top to its base, as has a prism or a pyramid, imaginary lines called **elements** are used to locate certain points on these figures. xy on Figs. 10 and 12 are angles between the sides of the prisms and pyramid, whereas $x'y'$ on Figs. 11 and 13 are imaginary lines that can be drawn on the surface of the cylinder or cone in order to locate certain points thereon. When the top of a cone or a pyramid is cut off, as in Fig. 14, the lower part of it is called the **frustum** of a cone or pyramid. The line bounding the surface of the top of the frustum of a cone is an **ellipse.**

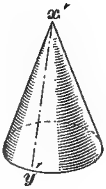


FIG. 13

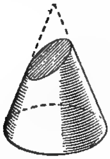


FIG. 14

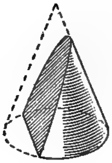


FIG. 15

7. There are three forms of surface that can be obtained by cutting a cone in different directions. These are: (1) the ellipse, where the cone is cut through from one side to the other, as in Fig. 14; (2) the **parabola,** where the cone is cut parallel with one side, as in Fig. 15; (3) the **hyperbola,** where the cone is cut parallel to the axis, as in Fig. 16. The parabola and hyperbola are not of much

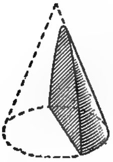


FIG. 16

general importance in design, but the ellipse is frequently made use of.

A solid figure bounded in every direction by a circle is called a **sphere,** and a line through its center being the diameter of its greatest circle is called the diameter of this sphere. Half of a sphere is termed a **hemisphere.**

INSTRUMENTS AND MATERIALS

8. All the **instruments** and **materials** usually required for instrumental drawing are mentioned in the following descriptions:

The **drawing board** should be made of well-seasoned, straight-grained pine, the grain running lengthwise. For this Course, the student will need a board of the following dimensions: length over all, 22½ inches; width, 16½ inches.

The drawing board illustrated in Fig. 17 is the one furnished in our students' drawing outfits and can be fully recommended as possessing the qualities a good and accurate board should have. It is made of several pieces of pine wood glued together to the required width of the board. A pair of hardwood cleats is screwed to the back of the board, the screws passing through the cleats in oblong slots with iron bushings, which allow the screws to move freely when drawn by the contraction and expansion of the board. Grooves are cut through half the thickness of the board over the entire back side. These grooves take the transverse resistance out of the wood and allow it to be controlled by the cleats, at the same time leaving the longitudinal strength nearly unimpaired. In order to provide a perfectly smooth working edge for the head of the **T** square to slide against, a strip of hardwood is let into the short edges

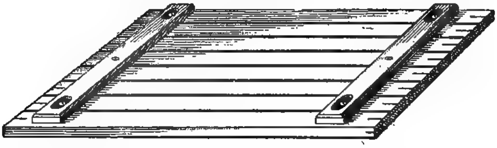


FIG. 17

of the board, and is sawed through in several places, in order to allow for the contraction and expansion of the board. The cleats also raise the board from the table, thus making it easier to change the position of the board. When in use, the board is placed so that one of the short edges is at the left of the draftsman, as shown in Fig. 18.

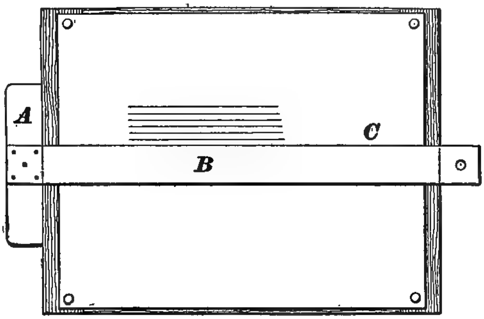


FIG. 18

9. The **T square** is used for drawing horizontal straight lines. The head *A* is placed against the left-hand edge of the board, as shown in Fig. 18. The upper edge *C* of the blade *B* is brought very near to the point through which it is desired to pass a line, so that the straightedge *C* of the blade may be used as a guide for the pen or pencil. It is evident that all lines drawn in this manner will be parallel.

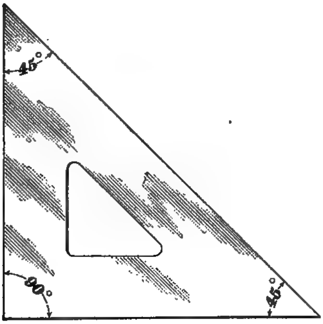


FIG. 19

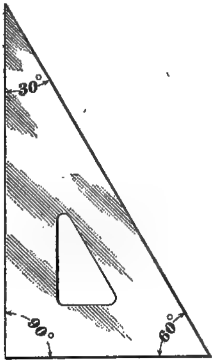


FIG. 20

Vertical lines are drawn by means of **triangles.** The triangles most generally used are shown in Figs. 19 and 20, each of which has one right angle. The triangle shown in Fig. 19 has two angles of 45° each, and that in Fig. 20 one of 60° and one of 30°. They are called *45°* and *60° triangles,* respectively. To draw a vertical line, place the **T** square in position to draw a horizontal line, and lay the triangle against it, so as to form a right angle. Hold both **T** square and triangle lightly with the left hand, so as to keep them from slipping, and draw the line with the pen or pencil held in the right hand, and against the edge of the triangle. Fig. 21 shows the triangles and **T** square in position.

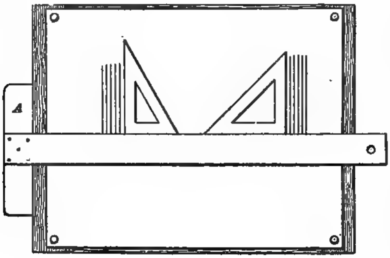


FIG. 21

10. For drawing parallel lines that are neither vertical nor horizontal, the simplest and best way, when the lines are near together, is to place one edge of a triangle, as *a b*, Fig. 22, on the given line *c d*, and lay the other triangle, as *B*, against one of the two edges, holding it fast with the left hand; then move the triangle *A* along the edge of *B*. The edge *a b* will be parallel to the line *c d*; and when the edge *a b* reaches the point *g*, through which it is desired to draw the parallel line, hold both triangles stationary with the left hand and draw the line *e f* by passing the pencil along the edge *a b*. Should the triangle *A* extend too far beyond the edge of the

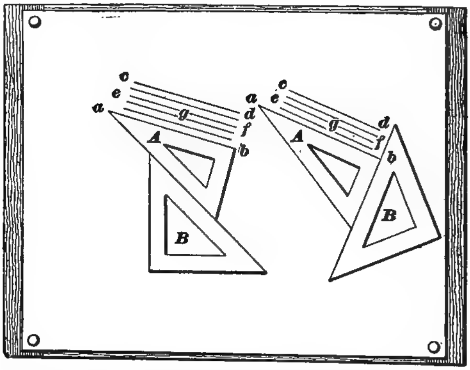


FIG. 22

triangle *B* after a number of lines have been drawn. hold *A* stationary with the left hand and shift *B* along to the edge of *A* with the right hand and then proceed as before.

11. A line may be drawn at right angles to another line which is neither vertical nor horizontal, as illustrated in Fig. 23. Let *c d* be the given line (shown at the left-hand side). Place one of the shorter edges, as *a b*, of the triangle *B* so that it will coincide with the line *c d*; then, keeping the triangle in this position, place the triangle *A* so that its long edge will come against the long edge of *B*. Now, holding *A* securely in place with the left hand, slide *B* along the edge of *A* with the right hand, when the lines *h i*, *m n*, etc. may be drawn perpendicular to *c d* along the edge *b f* of the triangle *B*. The dotted lines show the position of the triangle *B* when moved along the edge of *A*.

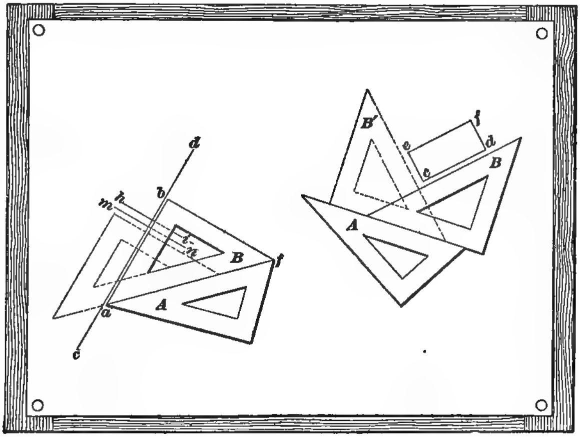


FIG. 23

12. The right-hand portion of Fig. 23 shows another method of accomplishing the same result, and illustrates how the triangles may be used for drawing a rectangular figure, when the sides of the figure make an angle with the T square such that the latter cannot be used.

Let the side *c d* of the figure be given. Place the *long* side of the triangle *B* so as to coincide with the line *c d*, and bring the triangle *A* into position against the lower side of *B*, as shown. Now, holding the triangle *A* in place with the left hand, revolve *B* so that its other short edge will rest against the long edge of *A*, as shown in the dotted position at *B'*. The parallel lines *c e* and *d f* may now be drawn through the points *c* and *d* by sliding the triangle *B* on the triangle *A*, as described in connection with Fig. 22. Measure off the required width of the figure on the line *c e*, reverse the triangle *B* again to its original position, still holding the triangle *A* in a fixed position with the left hand, and slide *B* on *A* until the long edge of *B* passes through *e*. Draw the line *e f* through the point *e*, and *e f* will be parallel to *c d*. The student should practice with his triangles before beginning drawing.

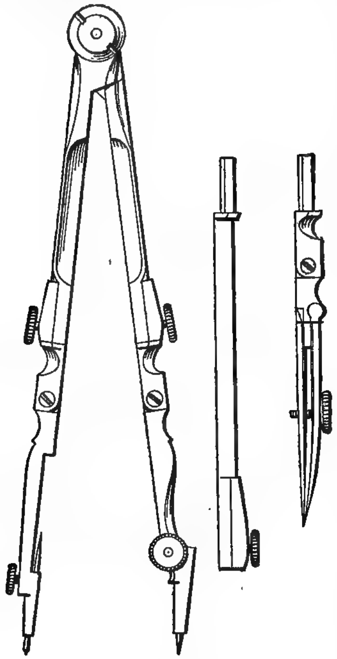


FIG. 24

13. The **compasses,** next to the T square and triangles, are used more than any other instrument. A pencil and pen point are provided, as shown in Fig. 24, either of which may be inserted into a socket in one leg of the instrument, for the drawing of circles in pencil or ink. The other leg is fitted with a needle point, which acts as the center about which the circle is drawn. In all good instruments, the needle point itself is a separate piece of round steel wire, held in place in a socket provided at the end of the leg. The wire should have a square shoulder at its lower end, below which a fine, needle-like point projects. The **lengthening bar,** also shown in the figure, is used to extend the leg carrying the pen and pencil points when circles of large radii are to be drawn.

The joint at the top of the compasses should hold the legs firmly in any position, and at the same time should permit their being opened or closed with one hand. The joint may be tightened or loosened by means of a screwdriver or wrench, which accompanies the compasses.

It will be noticed in Fig. 24 that each leg of the compasses is jointed; this is done so that the compass points may always be kept perpendicular to the paper when drawing circles, as in Fig. 27.

The style of compasses shown in Fig. 24 has what is called a *tongue joint*, in which the head of one leg has a tongue, generally of steel, that moves between two lugs on the other leg. Another common style of joint is the *pivot joint*, in which the head of each leg is shaped like a disk and the two disks are held together in a fork-shaped brace either by means of two pivot screws or by one screw penetrating both disks. The brace that forms a part of this joint is generally provided with a handle, as the shape of the joint makes it rather awkward to hold the compasses by the head, as is usual with instruments provided with tongue joints. In Fig. 25 is shown a common style of pivot joint.

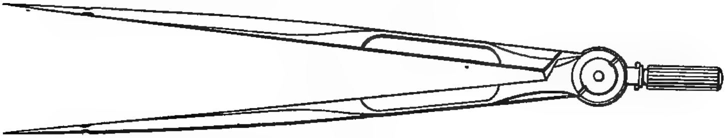


FIG. 25

14. The following suggestions for handling the compasses should be carefully observed by those who are beginning the subject of mechanical drawing. Any draftsman who handles his instruments awkwardly will create a bad impression, no matter how good a workman he may be. The tendency of all beginners is to use both hands for operating the compasses. This is to be avoided. The student should learn at the start to open and close them with one hand, holding them as shown in Fig. 26, with the needle-point leg resting between the thumb and fourth finger, and the other leg between the middle and forefinger. When drawing circles, hold the compasses lightly at the top between the thumb and forefinger, or thumb, forefinger, and middle finger as in Fig. 27. Another case where both hands should not be used is in locating the needle point at a point on the drawing about which the circle is to be drawn, unless the left hand is used merely to steady the needle point. Hold the compasses as

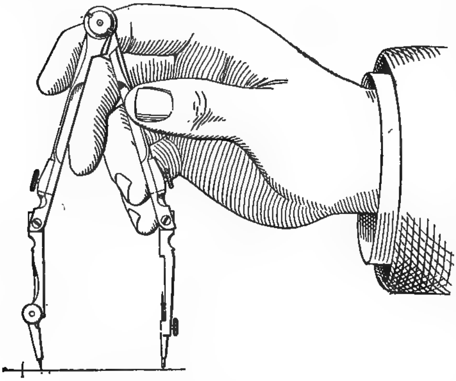


Fig. 26

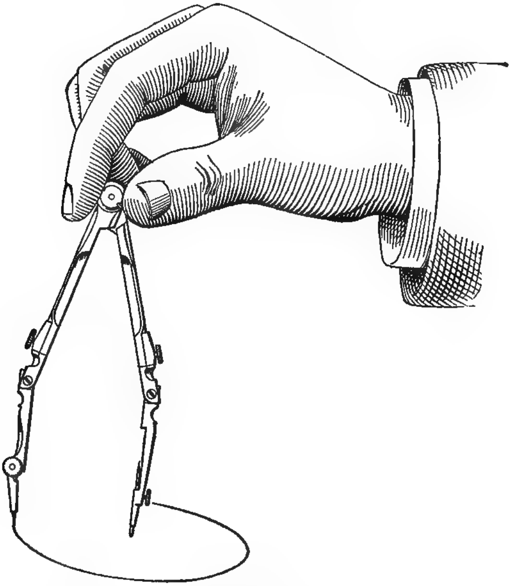


Fig. 27

shown in Fig. 26, and incline them until the under side of the hand rests on the paper. This will steady the hand so that the needle point can be brought to exactly the right place on the drawing. Having placed the needle at the desired point, and with it still resting on the paper, the pen or pencil point may be moved out or in to any desired radius, as indicated in Fig. 26. When the lengthening bar is used, both hands must be employed.

15. The compasses must be handled in such a manner that the needle point will not dig large holes in the paper. Keep the needle point adjusted so that it will be perpendicular to the paper, when drawing circles, and do not bear on it. A slight pressure will be necessary on the pen or pencil point, but not on the needle point.

16. The **dividers**, shown in Figs. 25 and 28, are used for laying off distances on a drawing, or for dividing straight lines or circles into parts. The points of the dividers should be very sharp, so that they will not punch holes in the paper larger than is absolutely necessary to be seen. Compasses are sometimes furnished with two steel divider points, besides the pen and pencil points, so that the instrument may be used either as compasses or dividers. This is the kind illustrated in Fig. 28. When using the dividers to space a line or circle into a number of equal parts, hold them at the top between the thumb and forefinger, as when using the compasses, and step off the spaces, turning the instrument alternately to the right and left. If the line or circle does not space exactly, vary the distance between the divider points and try again; so continue until it is spaced equally. When spacing in this manner, great care

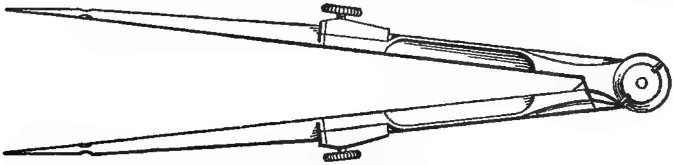


FIG. 28

must be exercised not to press the divider points into the paper; for, if the points enter the paper, the spacing can never be accurately done. The student should satisfy himself of the truth of this statement by actual trial.

17. The **bow-pencil** and **bow-pen,** shown in Fig. 29, are convenient for describing small circles. The two points of the instruments must be adjusted to the same length; otherwise, very small circles cannot be drawn. To open or close either of these instruments, support it in a vertical position by resting the needle point on the paper and bearing slightly on the top of it with the forefinger of one hand, and turn the adjusting nut with the thumb and middle finger of the same hand.

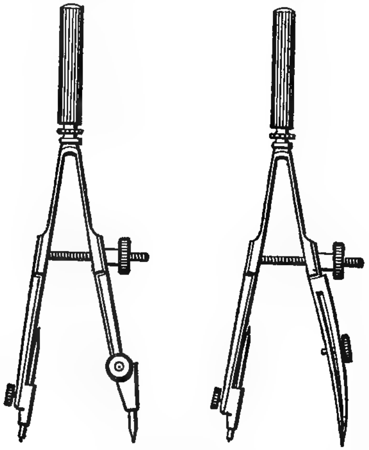


Fig. 29

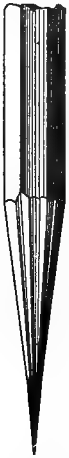


Fig. 30

18. Drawing Paper and Pencils.—The drawing paper recommended for this series of lessons is the Technical Supply Company's brown detail, in sheets 10″ × 15″. It takes ink well and withstands considerable erasing. The paper is secured to the drawing board by means of **thumbtacks.** Four are usually sufficient—one at each corner of the sheet (see Fig. 23). Place a piece of paper on the drawing board, and press a thumbtack through one of the corners about $\frac{1}{4}$ or $\frac{3}{8}$ inch from each edge. Place the **T** square in position for drawing a horizontal line, as before explained, and straighten the paper so that its upper edge will be parallel to the edge of the **T**-square blade. Pull the corner diagonally opposite that in which the thumbtack was placed, so as to stretch the paper slightly, and push in another thumbtack. Do the same with the remaining two corners. For drawing in pencil, an HH pencil of any reputable make should be used. The pencil should be sharpened as shown in Fig. 30. Cut the wood away so as to leave about $\frac{1}{4}$ or $\frac{3}{8}$ inch of the lead projecting, and sharpen it by rubbing it against a fine file or a piece of fine emery cloth or sandpaper that has been fastened to a flat stick. Do this frequently so as to keep a sharp point throughout each exercise. The lead for the compasses should be sharpened in the same manner as the pencil except that its edge should be chisel-shaped, so that it will wear down slowly. *Be sure that the compass lead is so secured that, when circles are struck in either direction, but one line will be drawn with the same radius and center.*

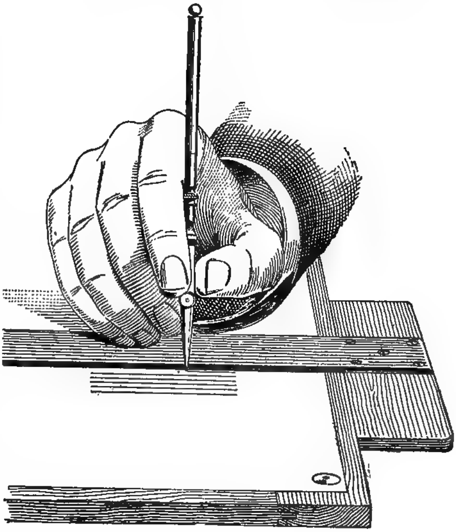


FIG. 31

19. Inking.—For drawing ink lines other than arcs of circles, the **ruling pen** (or *right-line pen*, as it is sometimes called) is used. It should be held as nearly perpendicular to the board as possible, with the hand in the position shown in Figs. 31 and 32, bearing lightly against the **T** square or triangle, along the edge of which the line is drawn.

After a little practice, this position will become natural, and no difficulty will be experienced.

20. The beginner will find that it is not always easy to make smooth lines. If the pen is held so that only one blade bears on the paper when drawing, the line will almost invariably be ragged on the edge where the blade does not bear. When held at right angles to the paper, as in Fig. 32, however, both blades will rest on the paper, and if the pen is in good condition smooth lines will result. The pen must not be pressed against the edge of the **T** square or triangle, as the blades will then close together, making the line uneven. The edge should serve as a guide simply.

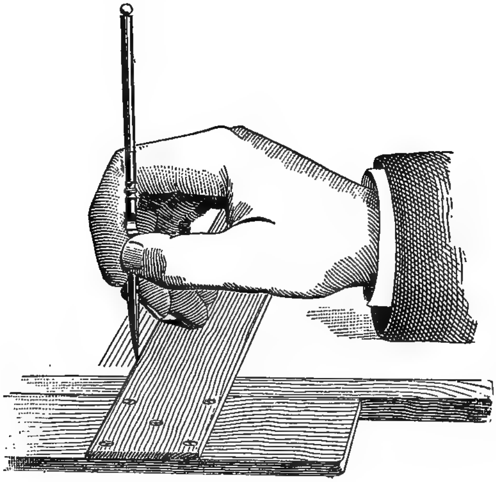


FIG. 32

In drawing circles with the compass pen, the same care should be taken to keep the blades perpendicular to the paper by means of the adjustment at the joint. In both the ruling pen and compass pen, the width of the lines can be altered by means of the screw that holds the blades together. The handles of most ruling pens can be unscrewed, and are provided with a needle point intended for use when copying maps by pricking through the original and the underlying paper, thus locating a series of points through which the outline may be drawn.

21. Drawing Ink.--The ink we recommend for the work in this Course is the Technical Supply Company's superior waterproof liquid India ink. A quill is attached to the cork of every bottle of this ink, by means of which the pen may be filled. Dip the quill into the ink and then pass the end of it between the blades of the drawing pen. Do not put too much ink in the pen, not more than enough to fill it for $\frac{1}{4}$ inch along the blades, otherwise the ink is liable to drop. Many draftsmen prefer to use stick India ink; and for some purposes this is to be preferred to the prepared liquid ink recommended above. In case the stick ink is bought, put enough water in a shallow dish (a common individual butter plate will do) to make enough ink for the drawing, then place one end of the stick in the water, and grind by giving the stick a circular motion. Do not bear hard on the stick. Test the ink occasionally to see if it is black. Draw a fine line with the pen and hold the paper in a strong light. If it shows brown (or gray), grind a while longer, and test again. Keep grinding until a fine line shows *black*, which will usually take from 15 minutes to $\frac{1}{2}$ hour, depending on the quantity of water used. The ink should always be kept well covered with a flat plate of some kind, to keep out the dust and prevent evaporation. The drawing pen may be filled by dipping an ordinary writing pen into the ink and drawing it through the blades, as previously described when using the quill. If liquid ink is used, all the lines on all the drawings will be of the same color, and no time will be lost in grinding. If stick ink is used, it is poor economy to buy a cheap stick. A small stick of the best quality, costing, say, a dollar, will last as long, perhaps, as five dollars' worth of liquid ink. The only reason for using liquid ink is that all lines are then sure to be of equal blackness and time is saved in grinding.

India ink will dry quickly on the drawing, which is desirable, but it also causes trouble by drying between the blades and refusing to flow, especially when drawing fine lines. The only remedy is to wipe out the pen frequently with a cloth. Do not lay the pen down for any great length of time when it contains ink; wipe it out first. The ink may sometimes be started by moistening the end of the finger and touching it to the point, or by drawing a slip of paper between the ends of the blade. *Always keep the bottle corked.*

22. Irregular Curves.—Curves other than arcs or circles are drawn with the pencil or ruling pen by means of curved or irregular-shaped rulers, called **irregular curves** (see Fig. 33). A series of points is first determined through which the curved line is to pass. The line is then drawn through these points by using such parts of the irregular curves as will pass through several of the points at once, the curve being shifted from time to time as required.

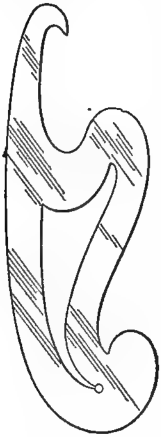


FIG. 33

It is usually difficult to draw a smooth, continuous curve. The tendency is to make it curve out too much between the points, thus giving it a wavy appearance, or else to cause it to change its direction abruptly where the different lines join, making angles at these points. These defects may largely be avoided by always fitting the curve to at least three points, and, when moving it to a new position, by setting it so that it will coincide with part of the line already drawn. It will be found to be a great help if the line be first sketched in freehand, in pencil. It can then be penciled over neatly, or inked, without much difficulty, with the aid of the irregular curve, since the original pencil line will show the general direction in which the curve should be drawn. Whenever the given points are far apart, or fall in such positions that the irregular curve cannot always be made to pass through three of them, the line must invariably be sketched in at first.

As an example, let it be required to draw a curved line through the points *a*, *b*, *c*, *d*, etc., Fig. 34. As just stated, a part of the irregular curve must be used that will pass through at least three points. With the curve set in the first position *A*, its edge is found to coincide with four points *a*, *b*, *c*, and *d*. The line may then be drawn from *a* around to *d*, or, better, to a point between *c* and *d*, since, by not continuing it quite to *d*, there is less liability of there being an angle where the next section joins on. For the next section of the line, the curve should be adjusted so as to coincide with a part of the section already drawn; that is, instead of adjusting it to points *d*, *e*, *f*, etc., it should be placed so as to pass through the point *c*, the part from *c* to *d* being coincident with the corresponding part of the first line drawn. The irregular curve is shown dotted in this position at *B*. Its edge

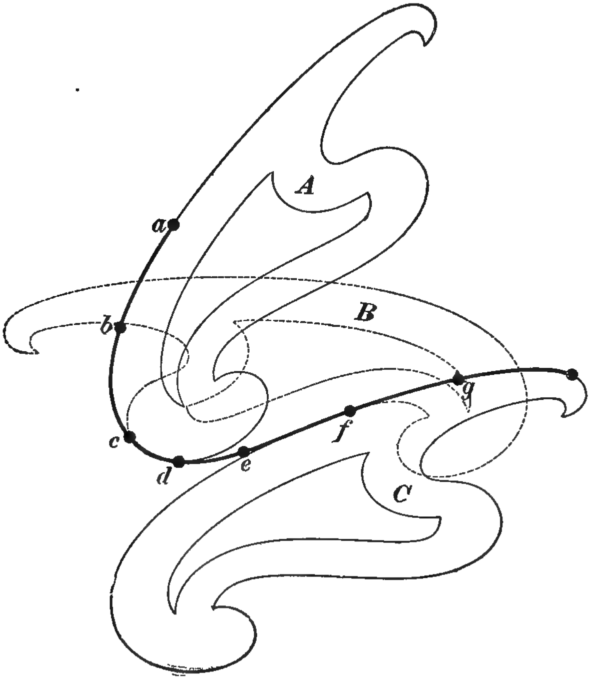


FIG. 34

passes through four points *c*, *d*, *e*, and *f*, and the line should be made to stop midway between the last two, as before.

Now, it will be noticed that the points *f* and *g* are so situated that the remainder of the line must curve up, instead of down, as heretofore, the change in curvature occurring at a point between *e* and *f*. In this case, therefore, it is not necessary for the curve to extend back to *e*, through which point the line has already been drawn, but it may be placed in position *C* with its edge just tangent to the line at the point where the curvature changes.

It is to be noticed that in inking with the irregular curve the blades of the pen must be kept tangent to its edge (i. e., the inside flat surface of the blades must have the same direction as the curve at the point where the pen touches the paper), which requires that the direction of the pen be continually changed.

23. The **scale** is used for obtaining measurements for drawings. The most convenient forms are the usual flat and triangular boxwood scales, having beveled edges, each of which is graduated for a distance of 12 inches. The beveled edges serve to bring the lines of division close to the paper when the scale is lying flat, so that the drawing may be accurately measured, or distances laid off correctly. The use of the graduations on scales will be explained when it is necessary to use the scale.

LETTERING

24. In instrumental drawing, all headings, explanatory matter, and dimensions should be neatly printed on the drawing. Ordinary script writing is objectionable.

It is usually difficult for beginners to letter well, and unless the student is skilful at it he should devote some time to practicing lettering before commencing the drawing. In correcting the plates, the lettering will be considered as well as the drawing. Many students think that it is only necessary to exercise special care when drawing the views on a plate, and that it is not necessary to take particular pains in lettering. This, however, is not the case, for, no matter how well the views may be drawn, if the lettering is poorly done, the finished drawing will not have a neat appearance. In fact, generally speaking, more time is required to make well-executed letters than to make well-executed drawings of objects. We earnestly request the student to practice lettering, and not to think that that part of the work is of no importance. The student should not be too hasty in doing the lettering. It takes an experienced draftsman considerable time to do good lettering, and no draftsman can perform this work as quickly as he can ordinary writing; therefore, no beginner should attempt to do what experienced draftsmen cannot do. In order to letter well, the work must be done slowly. Very frequently more time is spent in lettering a drawing than in inking in the objects represented. Instructions will be given in two styles of freehand lettering, both extensively used in American drafting rooms.

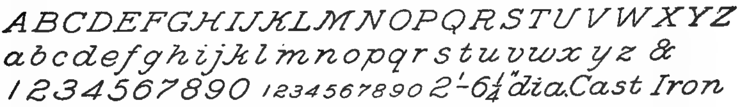

ABCDEFGHIJKLMNOPQRSTUVWXYZ
abcdefghijklmnopqrstuvwxyz &
1234567890 1234567890 2'-6¼" dia.Cast Iron

Fig. 35

With the exception of the large headings or titles of the plates, the style and size of all lettering used on the original drawing plates of this Section are shown in Fig. 35. This style, although a little more elaborate and difficult in execution than that shown in Fig. 39, is recommended on account of its greater neatness and legibleness. The two styles are very similar in the formation of the letters, and although the student is advised to select and use only one of the two on his drawings in this Section, he will find, after having mastered one of the styles, little difficulty in practicing the other.

When lettering, a Gillott's No. 303 pen should be used. The height of the capital letters should be $\frac{3}{32}$ inch, and of the small letters two-thirds of this, or $\frac{1}{16}$ inch. This applies to both styles of freehand lettering. Do not make them larger than this.

25. Before beginning to letter, horizontal guide lines should be drawn with the T square, to serve as a guide for the tops and bottoms of the letters (see Fig. 36). The outside lines should be $\frac{3}{32}$ inch apart for the capitals, and the two lower lines $\frac{1}{16}$ inch apart for the small letters. The letters should be made to extend fully up to the top, and down to the bottom, guide lines. They must not fall short of the guide lines, nor extend beyond them. Failure to observe this point will cause the lettering to look ragged, as in the second word in Fig. 36.

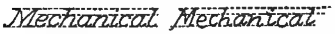
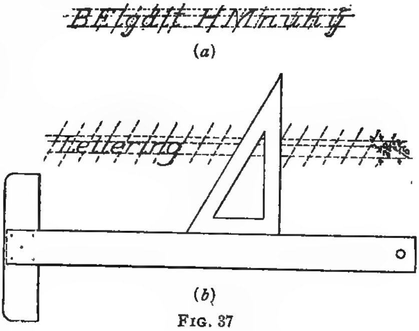


FIG. 36

26. It is very important that all the letters have the same inclination. For example, by referring to Fig. 37 (*a*). it will be seen that the backs of letters like *B*, *E*, *l*, *g*, *d*, *i*, *t*, etc. are parallel and slant the same way. This is also true of both sides of letters like *H*, *M*, *n*, *u*, *h*, *y*, etc. To aid in keeping the slant uniform, draw parallel slanting lines across the guide lines with the 60° triangle, as in Fig. 37 (*b*), and, in lettering, make the backs or sides of the letters parallel with these lines.



(*a*)

(*b*)

FIG. 37

27. A few points regarding the construction of the letters are illustrated in Fig. 38, in which the letters are shown on an enlarged scale. The capital letters *A*, *V*, *Y*, *M*, and *W* must be printed so that their general inclination will be the same as for the other letters. To print the *A*, draw the center line *a d*, having the common

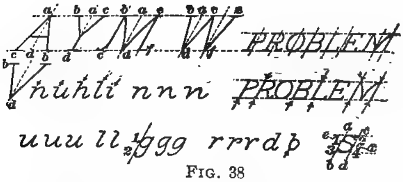


FIG. 38

slant; from *a* draw the sides *a c* and *a b*, so that the points *c* and *b* will each be $\frac{3}{64}$ inch distant from point *d*. The side *a b* will be nearly perpendicular to the guide lines. The *V* is like an inverted *A*, and is drawn in the same way, the line *b d* being nearly perpendicular.

To make the *Y*, draw the center line *a d*, having the common slant, which gives the slant for the base of the letter. The upper part of the *Y* begins a little below its center, and is similar to the *V*, though somewhat narrower, as the letter should be only $\frac{5}{64}$ inch wide at the top. Points *b* and *c* should be at equal distances from point *a*.

The two sides *b c* and *e f* of the *M* are parallel, and have the common slant. The *M* is made as broad as it is high, or $\frac{3}{32}$ inch. Having drawn the two sides, mark the point *d*, midway between the points *c* and *f*, and connect it with points *b* and *e*. The lines *b d* and *e d* should be slightly curved, as shown.

In the *W*, the two outside lines are not parallel, as in the *M*, but are farther apart at the top than at the bottom. Draw the line *a d*, having the common slant. Mark points *b* and *c*, which are exactly $\frac{1}{32}$ inch from the point *a*. From *b* and *c*, draw lines *b d* and *c d*. The other half of the *W* is like the first part, *c f* being parallel to *b d* and *e f* parallel to *c d*. It will be seen that the *W* is composed of two narrow *V*'s, each $\frac{1}{16}$ inch wide, the width of the whole letter being $\frac{1}{8}$ inch.

28. Capital letters like *P*, *R*, *B*, *L*, *E*, etc. should be printed so that their top and bottom lines will be exactly horizontal. This is illustrated in the two examples of the word *PROBLEM* in Fig. 38. In the first example, it will be noticed that the tops of the *P* and *R*, the bottom of the *L*, and the tops and bottoms of the *B* and *E*, all run in the same direction as the guide lines, and coincide with them. In the second example, these lines are not horizontal, which makes the word look very uneven. It is also to be noticed that these lines extend beyond the upright lines in the first word, and that cross-lines are used on the bottom of the *P* and *R*, on the top of the *L*, and on the *M*. In the second word, these lines are omitted at the points indicated by the arrows. These features are found on most of the other capitals.

The small letters *n*, *u*, *h*, *l*, *i*, etc. should have sharp corners at the points indicated by the arrows in Fig. 38. They look much better that way, and are less difficult to make, than when they have round corners. Following these letters are five groups of letters containing *n*, *u*, *l*, *g*, and *r*. The first letter of each group is printed correctly, while the letters following show ways in which they should *not* be printed. In the case of the *g*, point *2* should fall in a slanting direction under point *1*, the slant being the same as *a d* of the preceding letters. The difference between *d* and *b* and the construction of the *s* are also shown in the same figure. The *b* should be made rounding at the point indicated. As a guide in making the *s*, draw the two lines *a b* and *c d*, having the common slant. The *s* should now be drawn so that it will touch these lines at points *1*, *3*, and *4*, but *not* at point *2*. It will be an additional help if the line *e x* is also drawn as a guide for the middle portion of the *s*; but care should be taken not to have it slant more than shown in the copy.

The letters *a*, *o*, *b*, *g*, etc. should be full and round; do not cramp them. It will be necessary to follow the copy closely until familiar with it. Notice that the figures are not made as in writing, particularly the *6*, *4*, *8*, and *9* (see Fig. 35). Try to space the letters evenly. Letter in pencil first, and, if not right, erase and try again.

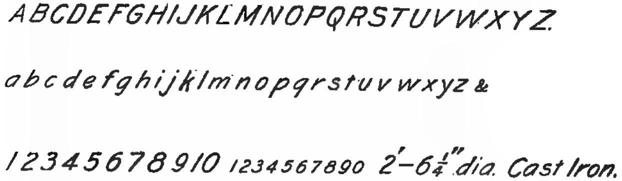

ABCDEFGHIJKLMNOPQRSTUVWXYZ
abcdefghijklmnopqrstuvwxyz &
12345678910 1234567890 2'-6¼" dia. Cast Iron.

FIG. 39

29. Another style of freehand lettering is shown in Fig. 39. This style is extensively used for the lettering of working drawings. It is more easily and rapidly made than the style previously described, and although not productive of as high degree of neatness in appearance will be found very useful and acceptable for general office work.

A comparison between the two systems will disclose a great similarity in the detail formation of the letters.

30. The horizontal and slanting guide lines are drawn exactly in the same manner as for the style previously described, and if not followed, the results will be similar. See the uneven appearance of the second word in Fig. 40.

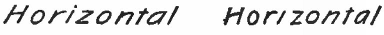


FIG. 40

31. By studying the formation of the letters carefully, it will be found that many of them are formed on the same principle, as shown in Fig. 41.

The ovals of the letters *a*, *b*, *d*, *g*, *p*, and *q* are formed exactly alike and have a slant of 45° with the horizontal. These ovals should be made a little wider at the top than at the bottom. Care should be taken that the straight downward strokes are made parallel to the slanting guide lines. The letters *c* and *e* are commenced in the same way, but the upper loop in *e* should be formed in such a manner that its axis will be at an angle of 45° with the horizontal. The *r* is made by having the down stroke parallel to the slanting guide line and the up stroke slightly curved in the same way as in the letter *n* (see Fig. 41). The strokes in the letters *j* and *f* are the same, with the position of the hook part reversed.

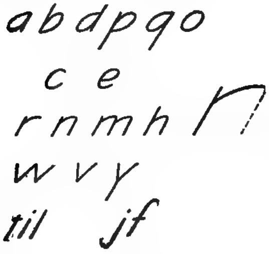


FIG. 41

32. The capital letters shown in Fig. 42 are formed very nearly in the same manner as those shown in Art. **27**, but differ slightly by omitting the short spurs that give to the letters a more finished appearance.

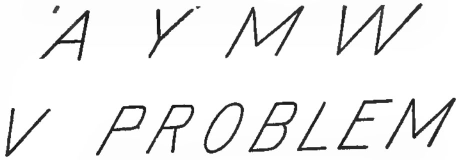


FIG. 42

In the capital *M*, however, there is a decided variation. The *M* is made with four strokes, putting in the parallel sides first. The two other strokes should join midway between these sides and at a distance from the top of about four-fifths of the height of the letter. These strokes, as will be seen, are straight and not curved.

33. The *numerals* should be $\frac{3}{32}$ inch high and of the style shown in Fig. 39; fractions should be $\frac{1}{8}$ inch high over all.

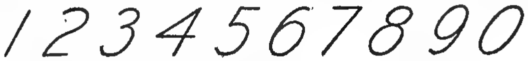


FIG. 43

In Fig. 43, the numerals are illustrated to a larger scale, and a comparison with the style shown in Fig. 35 will disclose several variations.

The loops of the *2*, *3*, *5*, *6*, and *9* should be formed so that their axes will be at an angle of 45° with the horizontal. It will be noted that the *7* differs widely from the style shown in Fig. 35, the down stroke not curving but having a straight slant of 45°. The axis of the *0* and the loops of the *8* should slant at an angle of 60°.

Diligent practice for a short time and careful observation of the forms of letters and numerals, as shown in Figs. 35 to 43, will soon enable the student to acquire skill and speed in this branch of drawing.

34. The alphabet shown in Fig. 44 is to be used for the large headings and titles of all the geometrical drawing exercises, as shown in the illustration of Exercise I, Sheet I. The letters of this alphabet are to be drawn $\frac{3}{8}$ inch high and $\frac{5}{16}$ inch wide, except the letters *M*, *W*, and *I*, which are $\frac{3}{8}$ inch, $\frac{1}{2}$ inch, and $\frac{1}{32}$ inch wide, respectively. The upper portion of certain letters is narrower than the lower part; thus, the tops of *B*, *E*, *K*, *S*, and *X* are $\frac{9}{32}$ inch wide, while the bottom is $\frac{5}{16}$ inch. All these letters are executed with the **T** square and triangle for the straight lines, and the compass for the curves. The thickness of the lines composing the letters is $\frac{1}{32}$ inch and it can be drawn with one single heavy stroke of

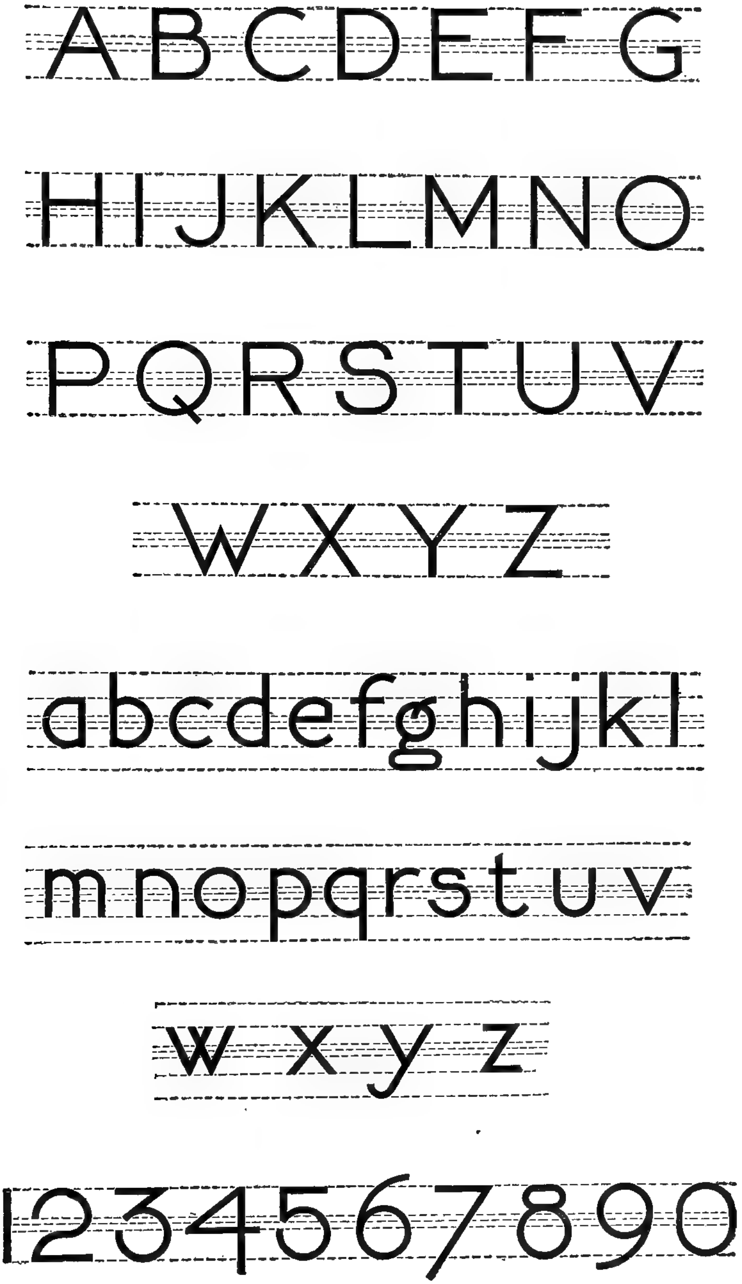

ABCDEFG
HIJKLMNO
PQRSTUV
WXYZ
abcdefghijkl
mnopqrstuv
wxyz
1234567890

Fig. 44

the drawing pen, or, with two lighter strokes, and afterwards filled in, whichever method the student prefers. There is less danger of blotting where the latter method is adopted but a greater uniformity of line can usually be secured by opening the nibs of the drawing pen to $\frac{1}{32}$ inch, and maintaining the uniform line in this manner.

The distance between any two letters in a word varies, but it should usually be about $\frac{1}{16}$ inch to $\frac{1}{8}$ inch. The student must use his judgment, however, in spacing letters, as a neat appearance can only be obtained where the apparent space each side of a letter is the same. For instance, in a letter like *f* or *j* in the lower alphabet, it is desirable that the letter preceding the *j* and following the *f* should be closer than the one on the other side, as the apparent space between these two letters is therefore made uniform. In the same manner, with the capitals, the letters *J* and *L* present similar characteristics. If a word should occur where the letter *J* follows *L*, it would be necessary to extend or space all the other letters in the word unusual distances apart in order to make the spacing appear even owing to the unusual distance between the vertical lines of the *L* and the *J*. On the other hand. if a word should occur where *L* follows *J*, it would be necessary to separate these two letters at an unusual distance because otherwise their vertical lines would come so close together that it would be practically impossible to get an appearance of even spacing, and the letters on the other sides would be held at a distance by the projecting lower portions of the *L* and *J*.

In drawing these letters, the ones with large curves like *C*, *G*, *O*, etc. have an outside radius of a trifle more than $\frac{3}{16}$ inch. The upper curves of the *B* and the *S* have an outside radius a trifle less than $\frac{3}{32}$ inch and the lower radius of the *B* and *S* is $\frac{1}{8}$ inch. The radius of the small letters is $\frac{1}{8}$ inch and their height $\frac{1}{4}$ inch, while the stems of *b*, *d*, *h*, etc. extend to the full height of the capital letters.

35. In order that the student may better understand the proportions of these letters, he will execute, in pencil, for criticism a complete alphabet of the capitals and small letters drawn as a separate exercise on a sheet of paper 9″ × 12″ and send it in with his first geometrical drawing exercise. Draw two horizontal lines $\frac{3}{8}$ inch apart with two other lines between them, each spaced $\frac{5}{32}$ inch inside as shown in the top line. The upper of these two inside lines establishes the positions for the middle horizontal lines of the *E*, *F*, *H*, etc., and the lower locates the horizontal line of the *A* and *G* and the inner point of the *M* and the *Y*.

36. The exercises in this Section are each to be executed on several sheets according to the printed instructions in the following pages. Each sheet of the exercises will be 9″ × 12″, outside measurement, with a border line $\frac{1}{2}$″ within the edge, except at the top, where the border will be $\frac{3}{4}$″ within the edge, thereby leaving the working space on each sheet $7\frac{3}{4}$″ × 11″. The problems are to be arranged as directed, and the entire work on each sheet should be completed in pencil before any of it is inked in.

When all the sheets of the first exercise are finished, they should be mailed to us at one time in one of the large envelopes provided for that purpose.

While we are correcting Exercise I, you are to proceed with the problems in Exercise II. In the meantime we will return your Exercise I to you. On receiving back Exercise I from us, you should note carefully all corrections and suggestions that may be sent with it. You will make better progress if you do not send us a new exercise until you have received back the last one and have had an opportunity to note our corrections and suggestions.

It is very essential that you strictly comply with these directions; since, otherwise, it will be impossible for us to point out your mistakes to you. This procedure should be strictly adhered to while you are drawing the first exercises of the Course—it will enable you to make rapid progress. Do not be

discouraged if there are a large number of corrections on your early exercises; we are merely pointing out ways in which the drawing or lettering can be improved so that your later exercises may be as nearly perfect as they can be made. No one can attain proficiency unless the work is criticized, and we are doing our best to help you succeed; we should not be doing our duty if we did not point out the defects. The *number* of corrections is no indication of our appreciation of the merits of the drawing.

On all exercises that you send to us, place your name and address in full on the back of the first sheet of each exercise, besides placing the date, name, and class letters and number below the margin on the face of each sheet as hereinafter directed. This should in no case be omitted, as delay in the return of your work will otherwise surely occur.

EXERCISES

37. Preliminary Directions.—Each exercise will be executed on from three to six sheets, each sheet being 9″ × 12″ over all and having a border line ½″ from each edge, except at the top, where the border will be ¾″, thus making the space on which the drawing is to be made 7¾″ × 11″. The sheet at first must be larger than this, so that the thumbtack holes may be cut out; the extra margin is also very convenient, when any work requires inking, for testing the pen, in order to see whether the ink is flowing well and whether the lines are of the proper thickness.

The first exercises will consist of practical geometrical problems that constantly arise in practice when laying out plans and designs. The method of solving each of these problems should be carefully memorized, so that it can be instantly applied when the occasion requires, without being obliged to refer to the text for help. Particular attention should be paid to the lettering. Whenever any dimensions are specified, they should be laid off as accurately as possible.

All drawings should be made as neatly as possible, and the penciling entirely finished before inking in any part of it. Great care should be taken in distributing the different views, parts, details, etc. on the drawing, so that when the drawing is completed, one view will not be so near to another as to mar the appearance of the drawing. The hands should be perfectly clean, and should not touch the paper except when necessary. No lines should be erased except when absolutely necessary; for, whenever a line has once been erased, the dirt flying around in the air and constantly falling on the drawing will stick to any spot where an erasure has been made, and it is then very difficult, if not impossible, to entirely remove it. Hence, all lines that are to be removed, or are liable to be changed, should be drawn lightly, that the surface of the paper may not be injured when erasing them. When it is desired to erase an ink blot or a line that has been inked in, use an *ink eraser* or *sand rubber*. Do not use a knife. After the erasure has been made, the roughened part of the surface of the paper can be smoothed by rubbing with some hard, smooth substance, as a piece of ivory or the handle of a knife.

EXERCISE I

38. Fasten a sheet of drawing paper to the board, as previously described, and draw the outlines of the size of the plate 9″ × 12″. Draw the border line all around inside of the edge, leaving the space inside for the drawing $7\frac{3}{4}''$ × 11″. Where the word *drawing* is used hereafter, it refers only to the space inside the border lines and the objects drawn on it. Study carefully the full-page illustration on Sheet I, which shows, on a smaller scale, exactly how your first drawing should look when completed. Divide the space within the border line into two rectangles by a vertical line through the center. Within these rectangles arrange each figure appropriately spaced. On the first five exercises, space for the lettering must be taken into account. For each of the sheets, the lettering will take up one or two lines. The height of all capital letters on these plates will be $\frac{3}{32}''$, and of the small letters two-thirds of this, or $\frac{1}{16}''$. The distance between any two lines of lettering will also be $\frac{3}{32}''$. The distance between the tops of the letters on the first line of lettering and the top border line of the drawing is to be about $\frac{5}{8}''$. This makes a very neat arrangement, if the figure is so placed that the outermost points of the bounding lines are equally distant from the sides of one of the equal rectangular spaces. The letter heading for each figure will be printed in heavy-faced type at the beginning of the directions explaining each problem. The student must judge for himself by the length of the heading whether it will take up one line or two, and make due allowance for the space it takes up. This is a necessary precaution, because the lettering should never be done *until the rest of the drawing is entirely finished and inked in.*

PROBLEM 1.—**To bisect a straight line.**

See Exercise I, Sheet I.

CONSTRUCTION.—Draw a straight line AB, $4\frac{1}{2}''$ long. With one extremity A as a center, and a radius greater than one-half of the length of the line, describe an arc of a circle on each side of the given line; with the other extremity B as a center, and the same radius, describe arcs intersecting the first two in the points C and D. Join C and D by the line CD, and the point P, where it intersects AB, will be the required point; that is, $AP = PB$, and P is the middle point of AB. Since CD is perpendicular to AB, this construction also gives a *perpendicular to a straight line at its middle point.*

PROBLEM 2.—**Through a given point, to draw a straight line parallel to a given straight line.**

See Exercise I, Sheet I.

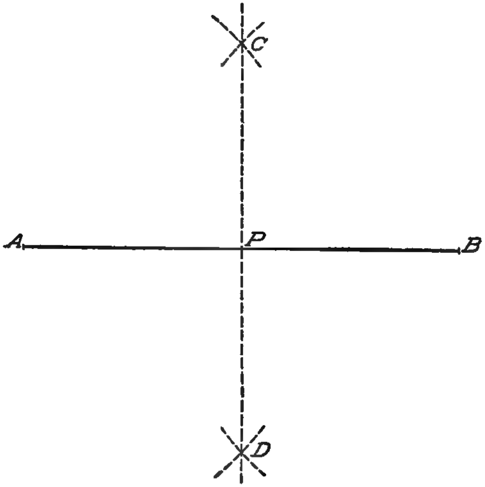
CONSTRUCTION.—Let P be the given point, and AB the given straight line $4\frac{1}{2}''$ long. With P as a center, and any convenient radius, describe an arc CD intersecting AB in D. With D as a center, and the same radius, describe the

Geometrical Drawing

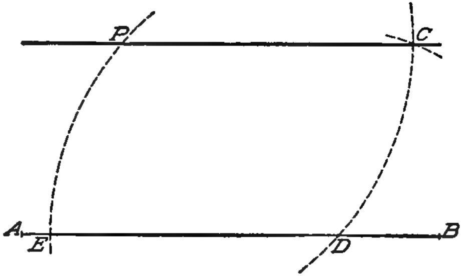
Exercise I.

Sheet I.

PROBLEM 1: To bisect a straight line.



PROBLEM 2: Through a given point to draw a straight line parallel to a given straight line.



Date

Time consumed in executing this sheet

Name of student, Class letters and Number

arc PE. With D as a center, and a radius equal to the chord of the arc PE, describe an arc intersecting CD in C. A straight line drawn through P and C will be parallel to AB.

PROBLEM 3.—**To draw a perpendicular to a straight line from a given point in that line.**

NOTE.—As there are two cases of this problem, requiring two figures on the sheet, the line of letters will be run clear across both figures, as shown in Exercise I, Sheet II.

Case I.—*When the point is at or near the center of the line.*

See Exercise I, Sheet II.

CONSTRUCTION.—Draw AB $4\frac{1}{2}''$ long. Let P be the given point. With P as a center, and any radius, as PD, describe two short arcs cutting AB in the points C and D. With C and D as centers, and any convenient radius greater than PD, describe two arcs intersecting in E. Draw PE, and it will be perpendicular to AB at the point P.

Case II.—*When the point is near the end of the line.*

See Exercise I, Sheet II.

CONSTRUCTION.—Draw AB $4\frac{1}{2}''$ long. Take the given point P about $\frac{3}{8}''$ from the end of the line. With any point O as a center, and a radius OP, describe an arc cutting AB in P and D. Draw DO, and prolong it until it intersects the arc in the point C. A line drawn through C and P will be perpendicular to AB at the point P.

PROBLEM 4.—**To draw a perpendicular to a straight line from a point without it.**

As in Problem 3, there are two cases.

Case I.—*When the point lies nearly over the center of the line.*

See Exercise I, Sheet III.

CONSTRUCTION.—Draw AB $4\frac{1}{2}''$ long. Let P be the given point. With P as a center, and any radius PD greater than the distance from P to AB, describe an arc cutting AB in C and D. With C and D as centers, and any convenient

Exercise I

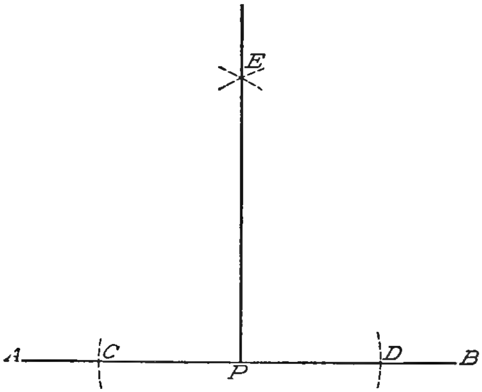
Title

Sheet II

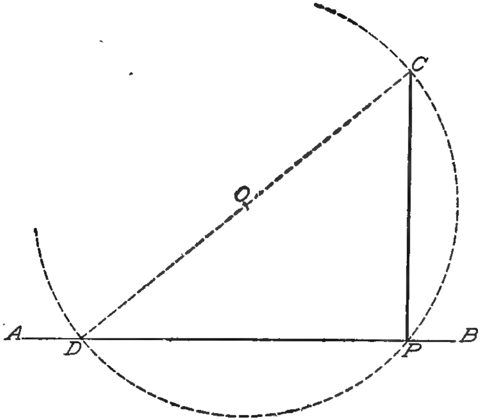
PROBLEM 3:

To draw a perpendicular to a straight line from a given point in that line.

Case I.



Case II.



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Name of Student, Class Letters
and Number

radius, describe short arcs intersecting in E. A line drawn through P and E will be perpendicular to AB at F.

Case II.—*When the point lies nearly over one end of the line.*

See Exercise I, Sheet III, Case II.

Construction.—Draw AB 4½″ long, and let P be the given point. With any point C on the line AB as a center, and the distance CP as a radius, describe an arc PED cutting AB in E. With E as a center, and the distance EP as a radius, describe an arc cutting the arc PED in D. The line joining the points P and D will be perpendicular to AB.

These four problems form Exercise I. They are to be carefully and accurately drawn in with lead-pencil lines and then inked in. It will be noticed that in Exercise I, the given lines are *light*, the required lines *heavy*, and the construction lines, which in a practical working drawing would be left out, are *light dotted.* This system must also be followed in the four exercises that are to follow. A single glance enables one to see at once the reason for drawing the figure, and the eye is directed immediately to the required line.

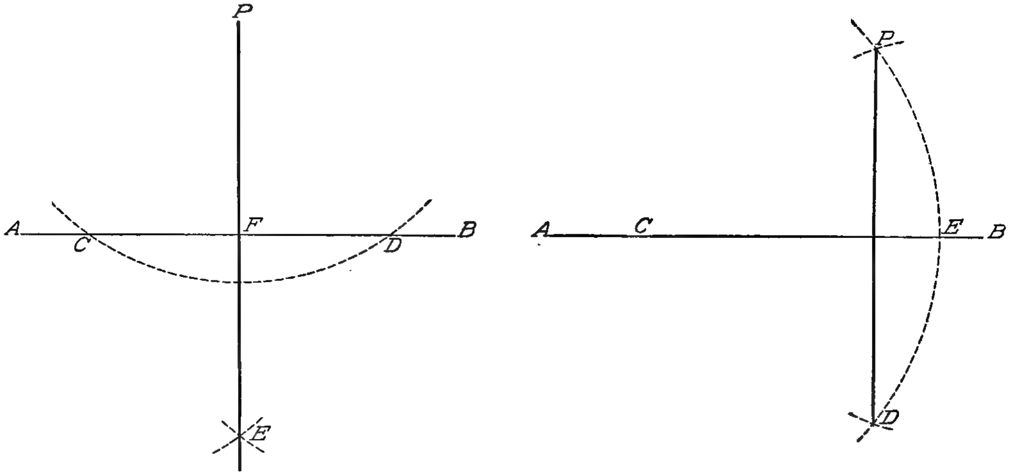
In the first five exercises, accuracy and neatness are the main things to be looked out for. The student should be certain that the lines are of *precisely* the length that is specified in the description. When drawing a line through two points, be sure that the line goes through the points; if it does not pass exactly through the points, erase it and draw it over again. If a line is supposed to end at some particular point, make it end there—do not let it extend beyond or fall short. Thus, in Problem 2 if the line PC does not pass through the points P and C, it is not parallel to AB. By paying careful attention to these points, the student saves himself a great deal of trouble in the future. *Do not hurry your work.* If the student desires to submit his drawing for criticism before inking it in, he may do so; or he may complete the exercise entirely finished in ink if he prefer. When the pencil drawing is sent to us, we criticize the work and send it to the student to be inked and returned to us for a second

Exercise I *Title* *Sheet III*

PROBLEM 4:

To draw a perpendicular to a straight line from a point without it.

Case I. Case II.



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criticism when he sends his next exercise. To ink the drawing, proceed as follows:

First ink in all of the light lines and light dotted lines (which have the same thickness); then ink in the heavy required lines after the pen has been readjusted. Now do the lettering (read again carefully Arts. **24** to **35** under the head "Lettering"), and finally draw the heavy border lines, which should be thicker than any other line on the drawing.

Since Exercise I requires three sheets, the student will letter each of them as follows: After carefully lettering the subject of each problem in its proper place, draw in each of the upper corners $\frac{1}{8}''$ above the border line of each sheet two parallel lines as described in Art. **25**. Between these lines, carefully letter the exercise number in the right corner and the sheet number in the left corner, as shown in the illustration on page 33. Then draw two similar parallel lines entirely across the bottom of the sheet $\frac{1}{8}''$ below the lower border line, and between these letter your name, class letters and number in the right corner, the date of completing the exercise in the left corner, and the entire time occupied in studying and drawing the problems on the sheet in the middle.

The object in putting the time occupied is to enable us to determine whether you have spent too much or too little time on the work as compared with the average student.

The title "Geometrical Drawing" should then be carefully drawn in with instruments on each sheet in the middle of the space at the top, as shown in the illustration on page 33, and according to the instructions given in Art. **34.** Clean the drawing by rubbing very gently with the eraser. Care must be exercised when doing this, or the inked lines will also be erased. It is best to use a so-called "sponge rubber" for this purpose, as it will not injure the inked lines. *If any part of a line has been erased or weakened, it must be redrawn.*

Then write with the lead pencil your name and address in full on the back of each sheet, after which place all the sheets of the exercise in the large envelope that was sent you, and send them to the Schools.

HINTS FOR EXERCISE I

39. *Do not forget to make a distinction between the weight of the given and required lines, nor forget to make the construction lines dotted.*

When drawing dotted lines, take pains to have the dots and spaces uniform in length. Make the dots about $\frac{1}{16}''$ long and the spaces only about one-third the length of the dots.

Try to get the work accurate. The constructions must be accurate, and all lines or figures should be drawn of the length or size previously stated. To this end, work carefully and keep the pencil leads very sharp, so that the lines will be fine.

The lettering on the first few plates, as well as on the succeeding plates, is fully as important as the drawing, and should be done in the neatest possible manner. Drawings sent in for correction with the lettering omitted will be returned for completion.

Do not neglect to trim the plates to the required size. Do not punch large holes in the paper with the dividers or compasses.

Be sure to have your class letters and number distinctly marked on *each* sheet of each exercise.

EXERCISE II

40. This exercise, as the previous one, will consist of three sheets of two figures each.

PROBLEM 5.—**To bisect a given angle.**

Case I.—*When the sides intersect within the limits of the drawing.*

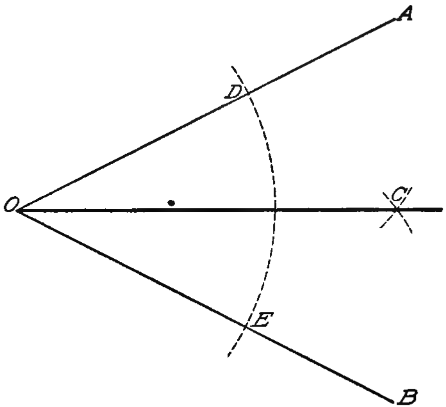
See Exercise II, Sheet I.

CONSTRUCTION.—Let AOB be the angle to be bisected. Draw the sides OA and OB $4\frac{1}{2}''$ long. With the vertex O as a center, and any convenient radius, describe an arc DE intersecting OA at D and OB at E. With D and E as centers, and a radius greater than the chord of half the arc DE, describe two arcs intersecting at C. The line drawn through C and O will bisect the angle; that is, $AOC = COB$.

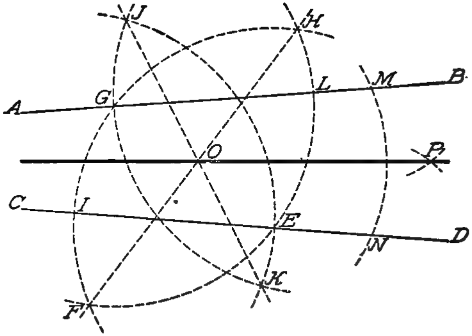
Exercise II *Title* *Sheet I*

PROBLEM 5

To bisect a given angle.
Case I.



To bisect a given angle.
Case II.



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Case II.—*When the sides do not intersect within the limits of the drawing.*

See Exercise II, Sheet I.

Construction.—Draw two lines, *A B* and *C D*, each $4\frac{1}{2}''$ long, and incline toward each other as shown. With any point *E* on *C D* as a center and any convenient radius, describe arc *F I G H*; with *G* as a center and same radius, describe arc *H L E F*, intersecting *F I G H* in *H* and *F*. With *L* as a center and same radius, describe arc *K G J*; with *I* as a center and same radius, describe arc *J E K*, intersecting *K G J* in *K* and *J*. Draw *H F* and *J K*; they intersect at *O*, a point on the bisecting line. With *O* as a center and the same or any convenient radius, describe an arc intersecting *A B* and *C D* in *M* and *N*. With *M* and *N* as centers and any radius greater than one-half *M N*, describe arcs intersecting at *P*. A line drawn through *O* and *P* is the required bisecting line.

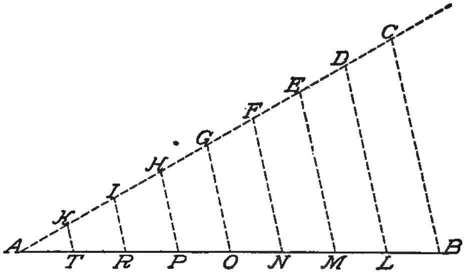
Problem 6.—**To divide a given straight line into any required number of equal parts.**

See Exercise II, Sheet II.

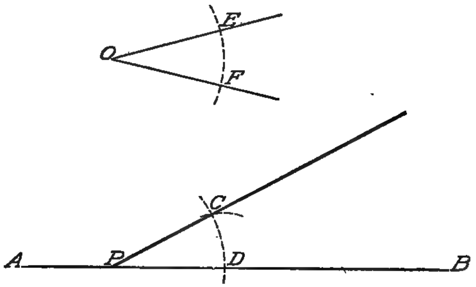
Construction.—*A B* is the given line $4\frac{1}{2}''$ long. It is required to divide it into eight equal parts. Through one extremity *A* of the line, draw an indefinite straight line *A C*, making any angle with *A B*. Set the dividers to any convenient distance, and space off eight equal divisions on *A C*, as *A K*, *K I*, *I H*, etc. Join *C* and *B* by the straight line *C B*, and through the points *D*, *E*, *F*, *G*, etc. draw lines *D L*, *E M*, etc. parallel to *C B*, by using the two triangles; these parallels intersect *A B* in the points *L*, *M*, *N*, etc., which are equally distant apart. The spaces *L M*, *M N*, *N O*, etc. are each equal to one-eighth *A B*. Proceed in a similar way for any number of equal parts into which *A B* is to be divided.

Another method is shown in Fig. 45. Draw *A B* as before, and erect the perpendicular *B C*. Now divide the length of *A B* by the number denoting the number of equal parts into which *A B* is to be divided, obtaining, in this case, *Exercise 11* *Title* *Sheet II*

PROBLEM 6: To divide a given straight line into any required number of equal parts.



PROBLEM 7: To draw a straight line through any given point on a given straight line to make any required angle with that line.



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Name of Student, Class Letters and Number

$3\frac{7}{16}'' \div 8 = \frac{55}{128}''$. As AC is longer than AB, the equal divisions AK, KI, etc. are longer than AT, TR, etc. and may be made any convenient length greater than $AB \div 8$. In this case, $\frac{1}{2}''$ is the most convenient fraction nearest to and greater than $\frac{55}{128}''$; hence, consider AK, KI, etc. to be each $\frac{1}{2}''$ in length, thus making the length of AC $8 \times \frac{1}{2}'' = 4''$. With A as a center and a radius equal to $4''$, describe an arc cutting BC in C, and draw AC. Then with a scale lay off $AK = KI = \text{etc.} = \frac{1}{2}''$, and project K, I, H, etc. on AB, in T, R, P, etc., the required points. The advantage of this method over the other is that the **T** square and triangle can be used throughout, thus making it very much easier to draw the parallels DL, EM, etc.

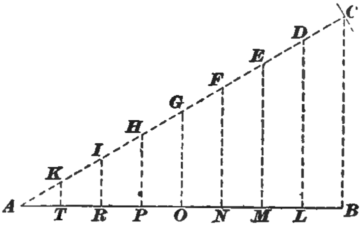


FIG. 45

The student, when drawing this exercise, is at liberty to use either of the methods given in this problem.

PROBLEM 7.—**To draw a straight line through any given point on a given straight line to make any required angle with that line.**

See Exercise II, Sheet II.

CONSTRUCTION.—AB is the given line $4\frac{1}{2}''$ long, P is the given point, and EOF is the given angle. With the vertex O as a center, and any convenient radius, describe an arc EF cutting OE and OF in E and F. With P as a center, and the same radius, describe an arc CD. With D as a center, and a radius equal to the chord of the arc EF, describe an arc cutting CD in C. A line drawn through the points P and C will make an angle with AB equal to the angle O, or $CPD = EOF$.

PROBLEM 8.—**To draw an equilateral triangle, one side being given.**

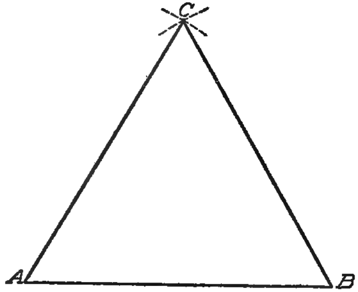
See Exercise II, Sheet III.

Exercise II

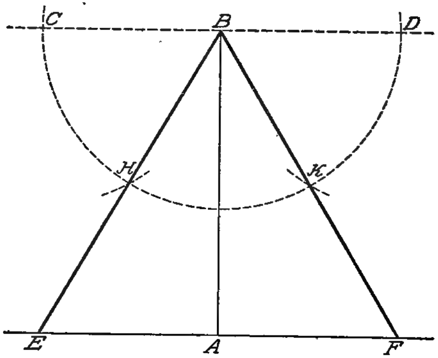
Title

Sheet III

PROBLEM 8: To draw an equilateral triangle, one side being given.



PROBLEM 9: The altitude of an equilateral triangle being given, to draw the triangle.



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Name of Student, Class Letters
and Number

Construction.—*A B* is the given side $3\frac{1}{4}''$ long. With *A B* as a radius, and *A* and *B* as centers, describe two arcs intersecting in *C*. Draw *C A* and *C B*, and *C A B* is an equilateral triangle.

Problem 9.—**The altitude of an equilateral triangle being given, to draw the triangle.**

See Exercise II, Sheet III.

Construction.—*A B* is the altitude $3\frac{1}{4}''$ long. Through the extremities of *A B* draw the parallel lines *C D* and *E F* perpendicular to *A B*. With *B* as a center, and any convenient radius, describe the semicircle *C H K D* intersecting *C D* in *C* and *D*. With *C* and *D* as centers, and the same radius, describe arcs cutting the semicircle in *H* and *K*. Draw *B H* and *B K*, and prolong them to meet *E F* in *E* and *F*. *B E F* is the required equilateral triangle.

This problem finishes Exercise II. The directions for inking in, lettering, etc. are the same as for Exercise I. In the upper corners of each sheet above the border line, letter the exercise number and sheet number, and in the lower corners and center below the border line letter the name, date, time, etc. as before. The title Geometrical Drawing should be placed on each Sheet. The three sheets of Exercise II should then be placed in the envelope and mailed to the Schools.

EXERCISE III

41. This exercise is to be arranged on three sheets like Exercises I and II, and the six following problems are to be drawn in a similar manner:

Problem 10.—**Two sides and the included angle of a triangle being given, to construct the triangle.**

See Exercise III, Sheet I.

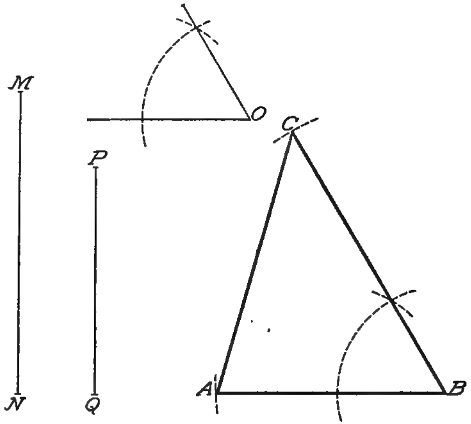
Construction.—Make the given sides *M N* $3\frac{1}{4}''$ long and *P Q* $2\frac{1}{2}''$ long. Let *O* be the given angle. Draw *A B*, and make it equal in length to *P Q*. Make the angle *C B A*

Exercise III

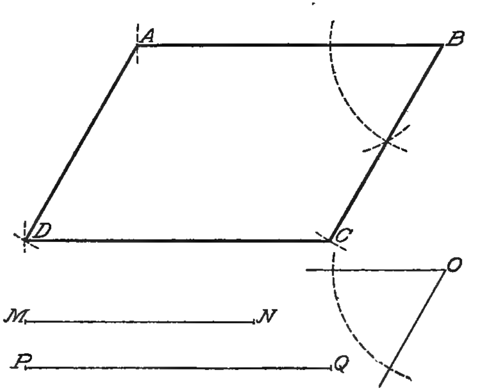
Title

Sheet I

PROBLEM 10: Two sides and the included angle of a triangle being given, to construct the triangle.



PROBLEM 11: To draw a parallelogram when the sides and one of the angles are given.



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equal to the given angle *O*, and make *CB* equal in length to the line *MN*. Draw *CA*, and *CAB* is the required triangle.

PROBLEM 11.—**To draw a parallelogram when the sides and one of the angles are given.**

See Exercise III, Sheet I.

CONSTRUCTION.—Make the given sides *MN* $2\frac{1}{2}''$ long and *PQ* $3\frac{1}{4}''$ long. Let *O* be the given angle. Draw *AB* equal to *PQ*, and draw *BC*, making an angle with *AB* equal to the given angle *O*. Make *BC* equal to *MN*. With *C* as a center, and radius equal to *PQ*, describe an arc at *D*. With *A* as a center, and a radius equal to *MN*, describe an arc intersecting the other arc in *D*. Draw *AD* and *CD*, and *ABCD* is the required parallelogram.

PROBLEM 12.—**An arc and its radius being given, to find the center.**

See Exercise III, Sheet II.

CONSTRUCTION.—*ACBD* is the arc, and *MN*, $2\frac{1}{4}''$ long, is the radius. With *MN* as a radius, and any point *C* in the given arc as a center, describe an arc at *O*. With any other point *D* in the given arc as a center, and the same radius, describe an arc intersecting the first in *O*. *O* is the required center.

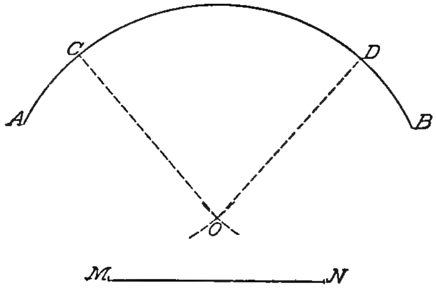
PROBLEM 13.—**To pass a circumference through any three points not in the same straight line.**

See Exercise III, Sheet II.

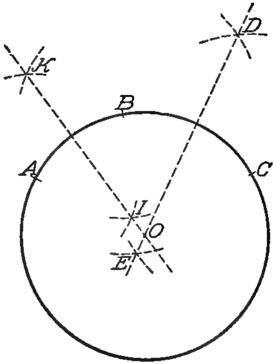
CONSTRUCTION.—*A*, *B*, and *C* are the given points. With *A* and *B* as centers, and any convenient radius, describe arcs intersecting each other in *K* and *I*. With *B* and *C* as centers, and any convenient radius, describe arcs intersecting each other in *D* and *E*. Through *I* and *K* and through *D* and *E*, draw lines intersecting at *O*. With *O* as a center, and *OA* as a radius, describe a circle; it will pass through *A*, *B*, and *C*.

Exercise III *Title* *Sheet II*

PROBLEM 12: An arc and its radius being given, to find the center.



PROBLEM 13: To pass a circumference through any three points not in the same straight line.



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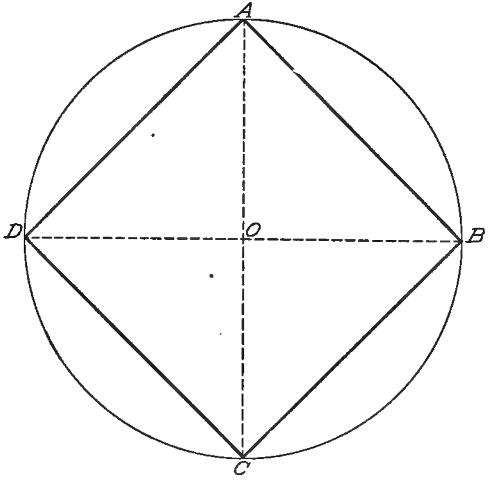
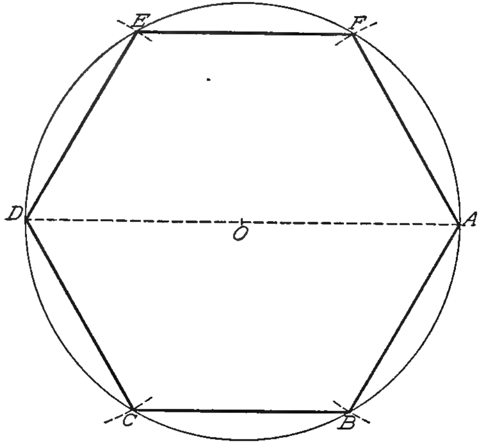
Exercise III *Title* *Sheet III*

PROBLEM 14: To inscribe a square in a given circle.



PROBLEM 15: To inscribe a regular hexagon in a given circle.



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PROBLEM 14.—**To inscribe a square in a given circle.**

See Exercise III, Sheet III.

CONSTRUCTION.—The circle *ABCD* is $4\frac{1}{2}''$ in diameter. Draw two diameters, *AC* and *DB*, at right angles to each other. Draw the lines *AB*, *BC*, *CD*, and *DA*, joining the points of intersection of these diameters with the circumference of the circle, and they will be the sides of the square.

PROBLEM 15.—**To inscribe a regular hexagon in a given circle.**

See Exercise III, Sheet III.

CONSTRUCTION.—From *O* as a center, with the compasses set to $2\frac{1}{4}''$, describe the circle *ABCDEF*. Draw the diameter *DOA*, and from the points *D* and *A*, with the compasses set equal to the radius of the circle, describe arcs intersecting the circle at *E*, *C*, *F*, and *B*. Join these points by straight lines, and they will form the sides of the hexagon. This problem completes Exercise III. The lettering of the exercise number, sheet number, name, class letters and number, etc., is to be completed above the upper and below the lower border lines as before; and the sheets mailed, in the large envelope, to the Schools.

EXERCISE IV

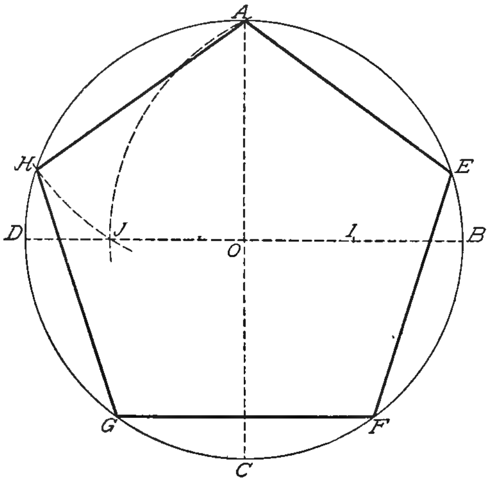
42. The first four problems of this exercise are more difficult than any of the preceding problems and will require very careful construction. All the sides of each polygon must be of exactly the same length, so that they will space around evenly with the dividers. The figures should not be inked in, but the pencil construction must be done very accurately. The preliminary directions for this plate are the same as for the preceding ones.

PROBLEM 16.—**To inscribe a regular pentagon in a given circle.**

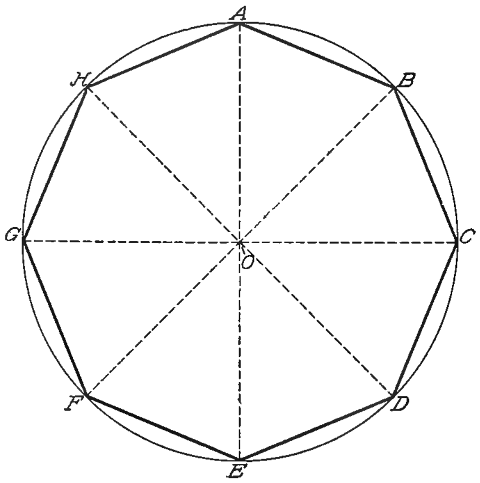
See Exercise IV, Sheet I.

Exercise IV Title Sheet I

PROBLEM 16: To inscribe a regular pentagon in a given circle.



PROBLEM 17: To inscribe a regular octagon in a given circle.



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Construction.—From *O* as a center, with the compasses set to $2\frac{1}{4}''$, describe the circle *A B C D*. Draw the two diameters *A C* and *D B* at right angles to each other. Bisect one of the radii, as *O B*, at *I*. With *I* as a center, and *I A* as a radius, describe the arc *A J* cutting *D O* at *J*. With *A* as a center, and *A J* as a radius, describe an arc *J H* cutting the circumference at *H*. The chord *A H* is one side of the pentagon.

Problem 17.—**To inscribe a regular octagon in a given circle.**

See Exercise IV, Sheet I.

Construction.—From *O* as a center, with the compasses set to $2\frac{1}{4}''$, describe the circle *A B C D E F G H*. Draw the two diameters *A E* and *G C* at right angles to each other. Bisect one of the four equal arcs, as *A G* at *H*, and draw the diameter *H O D*. Bisect another of the equal arcs, as *A C* at *B*, and draw the diameter *B O F*. Straight lines drawn from *A* to *B*, from *B* to *C*, etc. will form the required octagon.

Problem 18.—**To construct a regular octagon within a given square.**

See Exercise IV, Sheet II.

Construction.—Draw the square *a b c d* $4\frac{1}{4}''$ on each side. Draw the diagonals *a c* and *b d* intersecting at *o*. From *a b c* and *d* as centers, and with a radius *a o* equal to half of one diagonal, describe the arcs *e f*, *g h*, *i j*, and *k l*. Now draw the octagon from the points indicated.

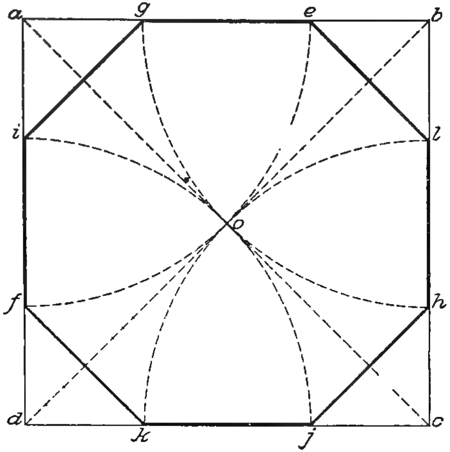
Problem 19.—**To construct an ellipse without instruments.**

See Exercise IV, Sheet II.

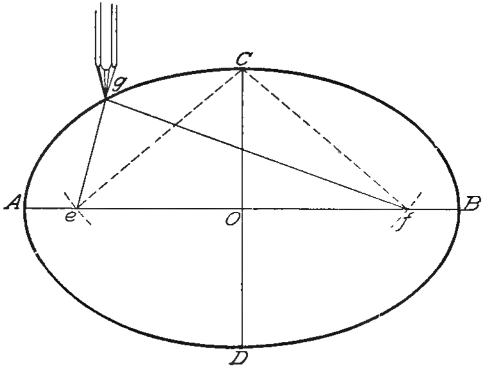
Construction.—Let *A B* and *C D* be the longitudinal and transverse axes of the ellipse $4\frac{1}{2}''$ and $3''$ long, respectively. From *C* lay off *c e* and *c f* equal to *A O*. Through *e* and *f* drive two needles, or small pins. Tie a piece of thread between these two pins, of such a length that it will reach also to *C* as shown by the dotted line *e C f*.

Exercise IV | Title | Sheet II

PROBLEM 18: To construct a regular octagon within a given square.



PROBLEM 19: To construct an ellipse without instruments.



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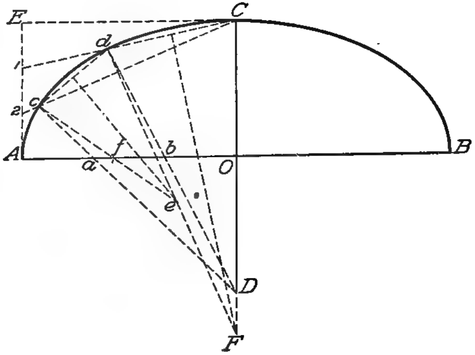
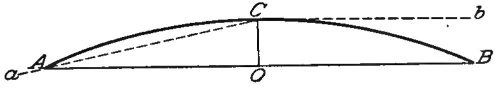
Exercise IV Title Sheet III

PROBLEM 20: To construct an ellipse approximately by means of circular arcs.



PROBLEM 21: To describe the arc of a circle too large for the dividers.



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Now, by inserting the point of a pencil under this thread and moving it from A to B, at the same time keeping the thread taut, one-half of the required ellipse will be described. The other half may be similarly described on the opposite side of the longitudinal axis.

PROBLEM 20.—**To construct an ellipse approximately by means of circular arcs.**

See Exercise IV, Sheet III.

CONSTRUCTION.—Lay off AB, $4\frac{1}{2}''$ as the longitudinal axis of the ellipse and CD $3''$ as the transverse axis. Draw AE parallel and equal to OC and divide it into three equal parts as shown at *1* and *2*. Divide AO into three equal parts as at a and b. Draw $C1$ and $C2$, and from D through a and b draw Dc and Dd cutting the lines $C1$ and $C2$ at c and d. Bisect Cd by a perpendicular line prolonged until it meets CD at F, and draw Fd. Draw cd and bisect it with a perpendicular intersecting Fd at e. Draw ec cutting AO at f. Then with F as a center draw the arc Cd, and with e as a center draw dc and with f as a center draw cA. The opposite side may be drawn in a similar manner. This method of drawing an ellipse is sometimes used in laying out an arch in a brick or stone wall as the joints in the masonry can be easily made to radiate from definite centers.

PROBLEM 21.—**To describe the arc of a circle too large for the dividers.**

See Exercise IV, Sheet III.

CONSTRUCTION.—Draw AB $4\frac{1}{2}''$ equal to the chord of the required arc, and OC $\frac{1}{2}''$ equal to the height of the arc above the center of the chord. Now, on a separate piece of paper $acbef$ draw the diagram shown in Fig. 46, making the angle aCb equal to the angle ACb in Problem 21. With a sharp knife or a pair of scissors cut off the top of the

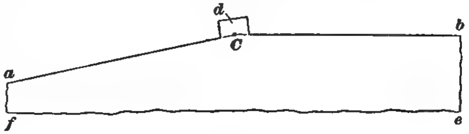


FIG. 46

paper on the lines *a C* and *C b*, Fig. 46, leaving a small portion at *d* as shown. Now drive two needles or small pins through the points *A* and *C*, Problem 21, and perforate the point *c* in Fig. 46 and place the piece of paper *a C b e f* over the drawing of Problem 21, so that the edges *a C* and *C b* rest against the pins driven through *A* and *C*. Now with the point of the pencil through the hole *C* slide the paper along against the pins and the required arc from *C* to *A* will be described. The other half from *C* to *B* may be similarly drawn by transferring the pin from *A* to *B* and moving the paper to the other side. The lettering for the sheets of this exercise should now be placed at the five accustomed places as before, and the sheets mailed to the Schools.

CONIC SECTIONS

43. In Fig. 47 are shown two similar cones *a b c* and *a d e*, which are in contact with each other at their vertexes *a*, and whose bases *b c* and *d e* are circular and at right angles to the axes *a f* and *a f′*. If either of the cones be intersected or cut by a plane that is parallel to one of its elements or sides, as *b e*, the line of intersection will be a *parabola*, as at *g h i*; but, if, instead of being parallel to the side *b e*, the cutting plane makes an angle with it, the curve formed by the intersection will be either an ellipse or a hyperbola, according to the angle. It will be an ellipse when the cutting plane is more nearly parallel with the base of the cone than it was in the case of the parabola, and passes through both sides as at *j k*; and the line of intersection will be a hyperbola when the cutting plane is more nearly

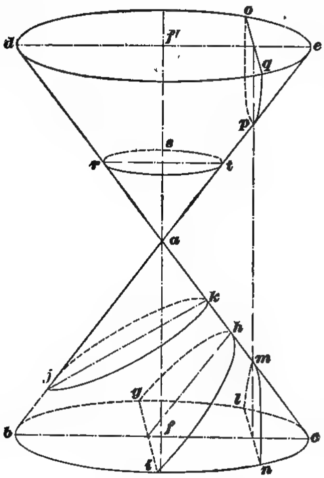


FIG. 47

perpendicular to the base than it was in the case of the parabola, as shown at *l m n* and *o p q*.

44. In the case of the hyperbola, the plane will always cut both cones, thereby giving two branches to the curve and these branches will be farther apart as the cutting plane recedes from the axes of the cones. The nearer the plane approaches the axes of the cones, the straighter will become the sides of the intersecting curve; and as the plane recedes from the axes, the rounder and nearer circular will be the intersection, though, no matter how closely the curve of intersection may approach the arc of a circle, it can never become absolutely circular in form.

The hyperbola becomes two intersecting straight lines when the plane passes through the vertex; these two lines are most divergent when the plane is parallel with the axes of the cones, and gradually become closer together as the plane approaches a position parallel with the side of the cone, where the hyperbola reaches its limit in a straight line. This straight line is the common limit of both hyperbola and parabola, as any deviation from it will produce one or the other of these curves, according to the direction of that deviation.

45. As the plane of the ellipse becomes more nearly parallel to the base of the cone, the ellipse approaches the form of a circle, which it finally becomes, when the axis of the cone and the cutting plane are perpendicular to each other, as at *r s t*, and as the plane of the ellipse approaches the vertex of the cone the ellipse diminishes in size until it reaches its limit in a point. From a point to a circle, then, is the limit of curvature of the ellipse.

EXERCISE V

PROBLEM 22.—**To draw an ellipse, the diameters being given.**

See Exercise V, Sheet I.

Case I.—CONSTRUCTION.—Let *B D*, the long diameter, or major axis, $4\frac{1}{2}''$ in length, and *A C*, the short diameter, or

Exercise V

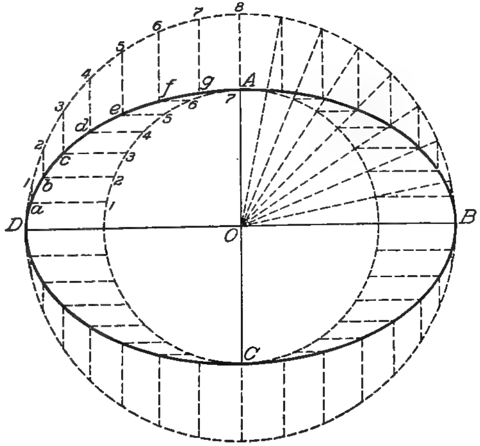
Title

Sheet I

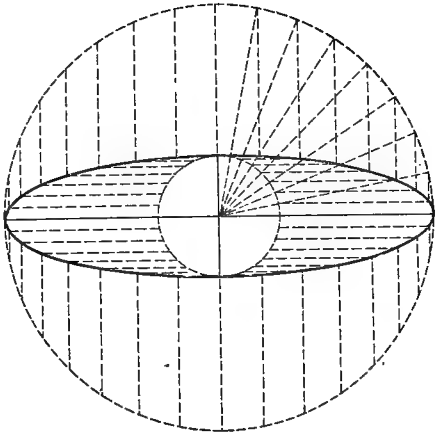
PROBLEM 22:

To draw an ellipse, the diameters being given.

Case I.



Case II.



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minor axis, 3″ in length, intersect at right angles to each other in the center *O*, so that $DO = OB$ and $AO = OC$. With *O* as a center, and *OC* as a radius, describe a circle; with the same center, and *OD* as a radius, describe another circle. Divide both circles into the same number of equal parts, as *1–2*, *2–3*, etc. This is best done by first dividing the larger circle into the required number of parts, beginning at the center line *AC*, and then drawing radial lines through the points of division on this circle, to the center *O* of the circles, as shown in the upper right-hand quarter of the figure. The radial lines will divide the smaller circle into the same number of parts that the larger one has been divided into. Through the points of division on the smaller circle, draw horizontal lines, and, through the points of division on the larger circle, draw vertical lines; the points of intersection of these lines are points on the ellipse. Thus, the horizontal line *3 c* and the vertical line *3 c* intersecting at *c* give the point *c* of the ellipse. Trace a curve through the points thus found by placing an irregular curve on the drawing in such a manner that one of its bounding lines will pass through three or more points, judging with the eye whether the curve so traced bulges out too much or is too flat. Then adjust the curve again, so that its bounding line will pass through several more points, and so on, until the curve is completed. Care should be taken to make all changes in curvature as gradual as possible, and all curves drawn in this manner should be drawn in pencil before being inked in. It requires considerable practice to be able to draw a good curved line in this manner by means of an irregular curve, and the general appearance of a curve thus drawn depends a great deal on the student's taste and the accuracy of his eye.

Case I.—Execute the same problems with a major axis of 4½″ and a minor axis of 1⅜″.

PROBLEM 23.—**To draw a parabola, the axis and longest double ordinate being given.**

See Exercise V, Sheet II.

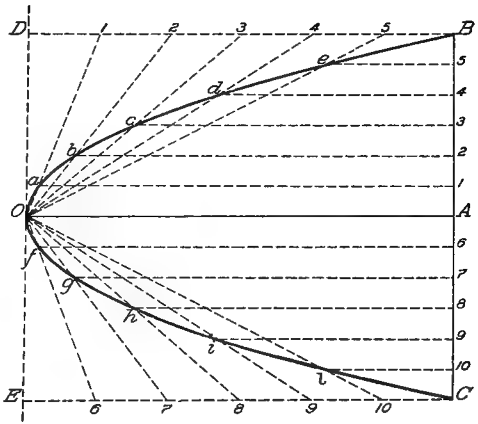
Exercise V

Title

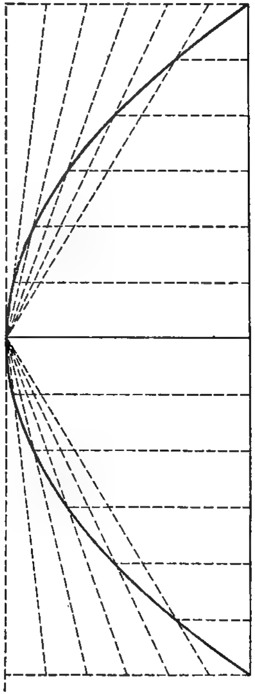
Sheet II

PROBLEM 23: To draw a parabola, the axis and longest double ordinate being given.

Case I.



Case II.



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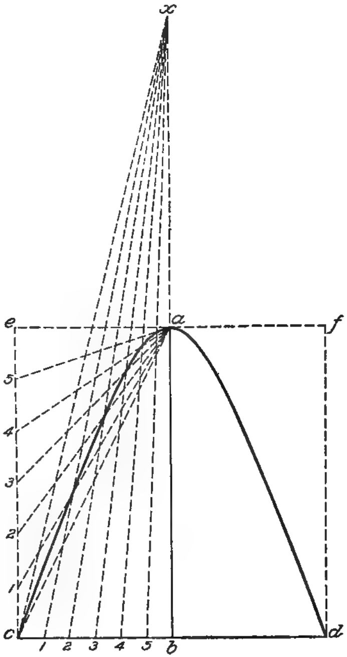
Exercise V

Title

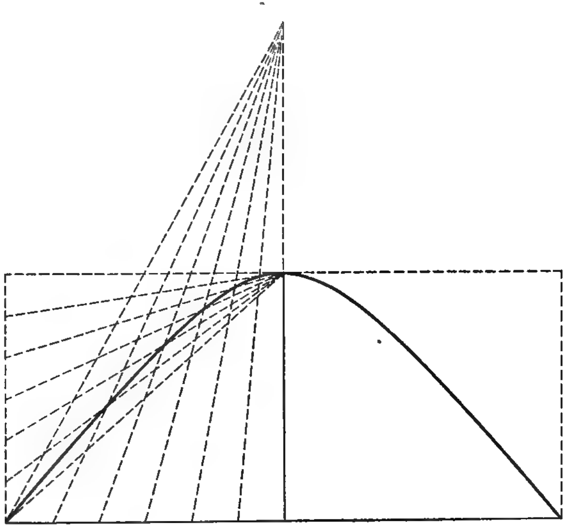
Sheet III

PROBLEM 24: To construct a hyperbola, the width and height being given.

Case I.



Case II.



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Case I.—EXPLANATION.—The curve shown in problem 23 is a parabola. The axis *O A*, which bisects the area included between the curve and the line *B C*, is 4½″ in length. Any line, *B A* or *A C*, drawn perpendicular to *O A*, and whose length is included between *O A* and the curve, is called an **ordinate.** Any line, as *B C*, both of whose extremities rest on the curve, and is perpendicular to the axis, is called a **double ordinate.** The point *O* is called the **vertex.**

CONSTRUCTION.—Lay off the axis *O A* its proper length, and the longest double ordinate *B C* 4″. *B A*, of course, equals *A C*. Draw *D E* through the other extremity of the axis and perpendicular to it; also draw *B D* and *C E* perpendicular to *B C* and intersecting *D E* in *D* and *E*. Divide *D B* and *A B* into the same number of equal parts, as shown (in this case six); through the vertex *O*, draw *O 1*, *O 2*, etc. to the points of division on *D B*, and through the corresponding points *1*, *2*, etc. on *A B*, draw lines parallel to the axis. The points of intersection of these lines *a*, *b*, *c*, etc., are points on the curve, through which it may be traced. In a similar manner, draw the lower half *O f g h i l C* of the curve.

Case II.—Execute this same problem with an axis of 2½″ and a double ordinate of 7″.

PROBLEM 24.—**To draw a hyperbola, the width and height being given.**

See Exercise V, Sheet III.

Case I.—EXPLANATION.—The axis *a b* 3¼″, is laid down perpendicular to the width *c d* 3¼″, in the same manner as for the parabola, and the rectangle *c d f e* is constructed with *e f* equal to the base of the hyperbola, and the height *c e* equal to the axis *a b*. Divide one-half the base and also each side into any number of equal parts, and connect the points of division on the sides with the vertex *a* by means of the lines *a 1*, *a 2*, *a 3*, etc. The points of division on the base are connected by lines to some point *x* about 7″ above *b* the line of the axis *a b* extended; the points of intersection of these two series of lines will determine points on the hyperbolic curve, taking the lines in the order as they recede from point *c*; *x* can be at any distance above *a*, and the curved lines *a c* and *a d* will approach more nearly the curves of the parabola as the point *x* becomes more remote. On the other hand, the nearer the point *x* is to the vertex *a*, the more *a c* and *a d* will approximate to a straight line, and when points *x* and *a* coincide, the lines *a c* and *a d* will be straight lines.

Case II.—Execute this same problem within a rectangle whose base *c d* is 5½″ and whose height *c e* is 2½″.

PROJECTION DRAWING

PROJECTIONS

1. Introduction.—When an instrumental or geometrical drawing is made to represent a definite object in a definite position, it is termed a **projection drawing**, as the form and dimensions of the object are projected on the paper in their actual proportions, thereby giving a diagram that can be scaled or measured so as to serve as a pattern.

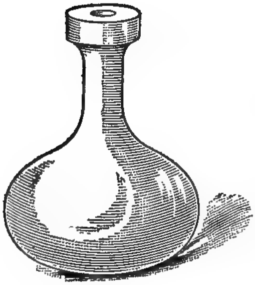

FIG. 1

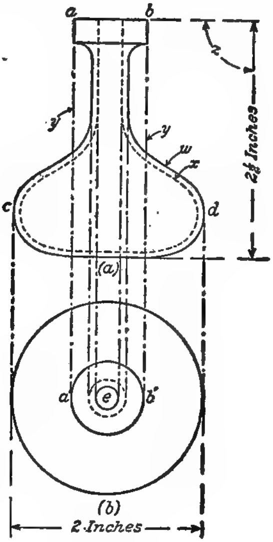

FIG. 2

In all branches of design wherein working drawings are required, projection drawing forms the basis of the operations where the resulting fabric is to be a solid article. In Fig. 1 is shown a perspective sketch of a small decanter,

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which conveys to the observer all its details of form and material, but does not give any exact dimension from which a similar article could be produced. In Fig. 2, however, is shown a projection drawing of the same decanter, (*a*) being the side view, usually called the **elevation,** while (*b*) is the top view, usually called the **plan.** The straight line representing the upper edge of the neck *a b* appears in plan as a circle, *a' b'*, and the full width of the decanter *c d* appears in plan as a larger circle; the hole through the neck of the decanter, which does not show at all in the elevation (except by a dotted line that indicates the thickness of the glass), appears in the plan as the small circle *e*. This, then, is the simple principle of projection drawing, and whether the projected object be a line, a surface, or a solid, its entire form can be expressed in two or three drawings, showing the views of the top and of one or two sides.

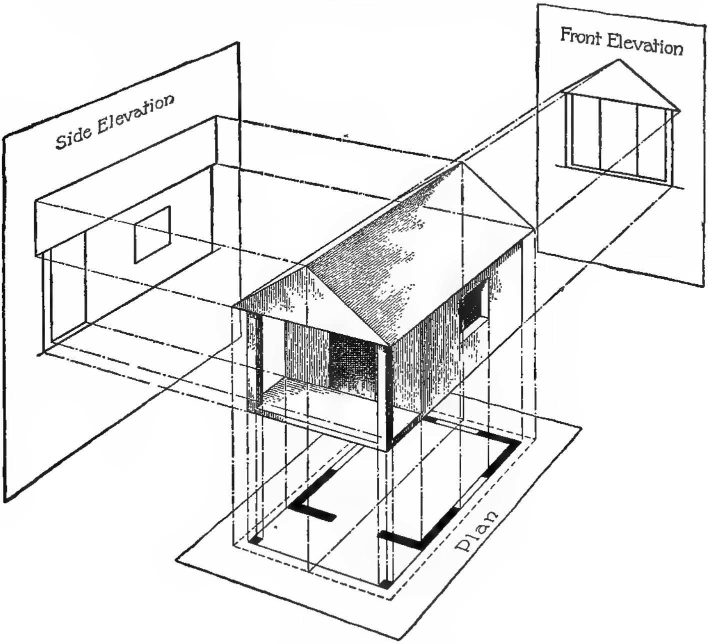

FIG. 3

In making projection drawings, it is assumed that the eye is always in front of each particular portion of the object, no matter how large it may be, and that the form projected in the plan is derived from outlines obtained by projecting each important point of the object to the drawing paper or to a plane, held in a vertical or horizontal position, according to whether we are making the elevation or the plan. In Fig. 3 is shown the application of this principle for a small building where the front elevation, side elevation, and plan are shown on three sheets to which they have been projected by imaginary lines drawn from the several parts of the building.

2. In making projection drawings, four general kinds of line are used.

The **full line** is used for indicating outlines of a figure and the parts that can be readily seen in their indicated positions, as *w*, Fig. 2.

The **dotted line,** consisting of a series of dashes about $\frac{1}{16}$ inch long, is used to indicate the position and shape of some part of the object that exists in the view projected, but is hidden by something being in front of it, as *x*, Fig. 2, where a dotted line is used to indicate the interior line of the decanter.

The **broken and dotted line,** consisting of a long dash and a dot or short dash repeated regularly, is used to indicate the center line of figures or parts of a figure, to show a line on which a section or cut has been taken, or to project the details of a part from one view to another, as *y*, Fig. 2, where the width of the top $a\,b$ is projected into the plan at $a'\,b'$ by means of broken and dotted lines $a\,a'$ and $b\,b'$.

The **broken line,** consisting of a series of long dashes, is used almost exclusively for indicating the points between which the dimensions are taken, as at *z*, Fig. 2.

A specific use of any one of these lines for any particular purpose is not fixed by any rule, and different individuals adopt for themselves whichever arrangement best suits their fancy, but the above system will be followed in this Section and the student is to govern himself accordingly.

In general practice, the draftsman does not make any distinction between different forms of lines in his pencil drawing, but gives the distinguishing characteristics when he inks or traces his drawing.

EXERCISE I

3. Exercise I consists of four sheets containing four simple surfaces and eight solids. Each figure represents a plan and elevation. The sheets on which this and all subsequent exercises in this Section should be executed are to be 9″ × 12″, outside measurement. A border line is to be drawn a distance of ½″ from the outside edges, except at the top where the width of the border should be ¾″ in order to allow for the printing of the title. Sheets I and III should have their long dimension vertical, while Sheets II and IV have their long dimension horizontal; and all four sheets should have a line in pencil through the center parallel with the longer sides. Sheets I and III also have horizontal pencil lines dividing them 7″ above the lower border and vertical lines 2″ each side of the center; the last to form the center lines for the figures drawn.

PROBLEM 1. Exercise I, Sheet I.—Draw Fig. 1, which is a disk, showing its plan as a circle *c d* and its elevation, a straight line *a b*. The center of the horizontal projection is 1½″ above the horizontal dividing line and on the vertical center line of the upper left-hand rectangle; and the radius is 1¼″. The vertical projection, or elevation, of this disk can be drawn at any convenient point above it, say ¼″, its length being limited by the projection lines drawn tangent to each side of the circle. Fig. 1 then shows by its plan and elevation that it represents a disk whose thickness is equal to that of a single line.

PROBLEM 2.—Draw Fig. 2, whose plan is precisely the same as Fig. 1, with the center of the plan 1½″ above the lower border line and on the vertical center line of the rectangle. The elevation of Fig. 2, however, appears as a rectangle 3¼″ high with its base ¼″ above the top of the plan, thus showing that, although the plan is the same as Fig. 1, *Exercise I* *Title* *Sheet I*

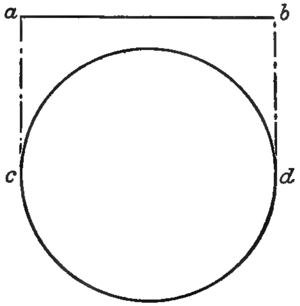

Fig. 1

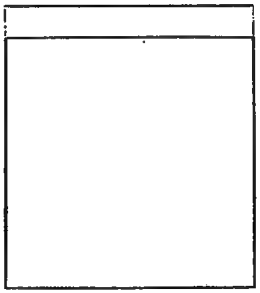

Fig. 3

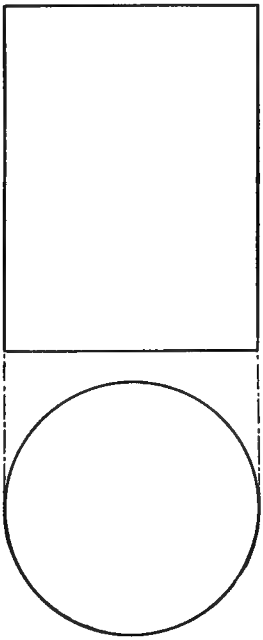

Fig. 2

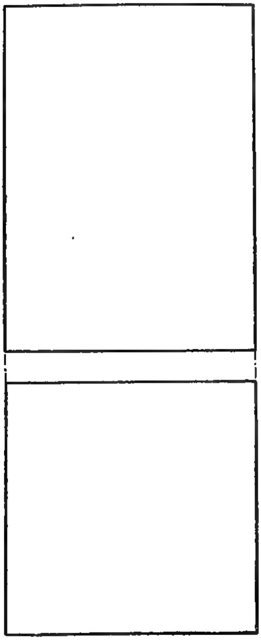

Fig. 4

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the thickness or height is 3¼″; therefore, it represents a cylinder instead of a disk.

PROBLEM 3.—Draw the elevation as a straight line 2½″ in length, the same as the elevation of Fig. 1 and on a line with it; i. e., about ½″ below the upper border line. The plan, however, is a square 2½″ on each side, showing that this figure is a square surface, such as a piece of tin, metal, paper, card, etc.

PROBLEM 4.—Fig. 4 is a plan identical with the plan of Problem 3, but the elevation, being a rectangle similar to the elevation of Fig. 2, shows that this object has a thickness of 3¼″, and is therefore a square prism.

Figs. 1 and 2 have the same plan, but the elevations show that they have a different thickness, and therefore while one is a disk the other is a cylinder. In Figs. 3 and 4, the elevation shows that one is a square surface and the other a square prism. Figs. 1 and 3, and 2 and 4 have the same elevations, but the plans show them to be different; thus, each is identified by a combination of its two projections.

PROBLEM 5. Exercise I, Sheet II.—To draw Figs. 5 and 6, divide the sheet through its longer dimension by a vertical center line, thus making two rectangles 8″ × 5½″ inside the border lines. Draw vertical center lines through these smaller rectangles. The plan of Fig. 5 is the same as that of Figs. 1 and 2, a circle with a radius of 1¼″. This circle has its center about 2¼″ above the lower border line. The elevation of Fig. 5, however, appears as a triangle, thereby indicating that the solid is a cone. The height of this triangle is the same as the cylinder of Fig. 2, namely, 3¼″ and has its base 4″ above the lower border line.

PROBLEM 6.—Fig. 6 has for the elevation a triangle, also identical with that of Fig. 5 (and in drawing it place the base on a level with that in Fig. 5), but the plan, being square, shows that Fig. 6 represents a square pyramid.

4. In these six simple problems are illustrated the general principles of projection drawing; and in every ordinary instance a combination of two drawings showing the plan

Exercise 1 *Title* *Sheet II*

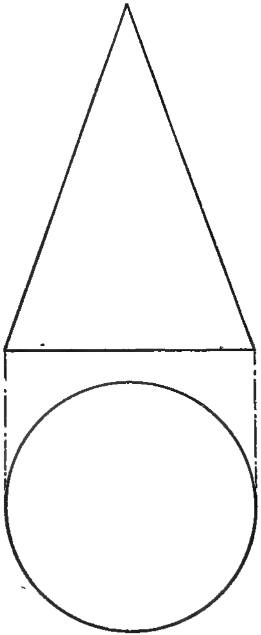

Fig. 5

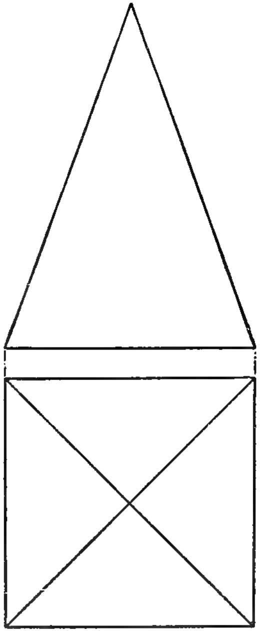

Fig. 6

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and one elevation will convey a general idea of the outlines of any regular solid. In Problems 7 to 12, no new principle is introduced, as Problems 7 and 8 are drawings of polygonal surfaces; Problems 9 and 10, polygonal prisms; and Problems 11 and 12, polygonal pyramids.

PROBLEMS 7 TO 12. Exercise 1, Sheets III and IV.—The figures are to be arranged on the drawing paper in the same manner as were the figures on Sheets I and II. The figures are to be drawn according to the dimensions given for the problems on Sheets I and II, except the plans of Figs. 8, 10, and 12, which are to be made $2\frac{5}{16}''$ between parallel sides. The octagons in the plan of these figures can be readily constructed according to Problem 18, *Geometrical Drawing*. Draw these figures in the exercise as directed, but observe that in the elevation the angles or corners that appear at *a* and *b* in Fig. 9 are shown in the elevation as vertical lines extending through the surface. In Fig. 11, these lines in extending through the surface from the corners *a* and *b* converge to the apex of the pyramid, thus indicating the character of the solid.

Having completed the four sheets, carefully letter the title PROJECTIONS, the exercise number, and sheet number at the top of each sheet and insert the name, class letters and number, date, time consumed, etc. at the bottom in their proper places, as heretofore. Mail the four sheets *flat* to the Schools for correction.

After estimating the time spent on this work, calculate approximately the amount of study put on the text from the commencement to the time you finish this sheet; when estimating the time for the second sheet, estimate the time spent in studying and actual work since the completion of this sheet. In this way it is possible to tell what progress is being made and advise accordingly. This amount of time in each case should be placed immediately below the border line and in the center, at the place marked *time*.

Exercise I *Title* *Sheet III*

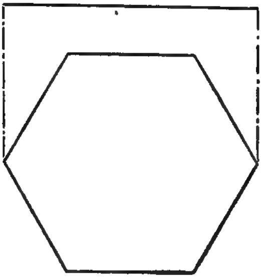

Fig. 7

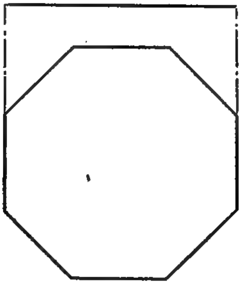

Fig. 8

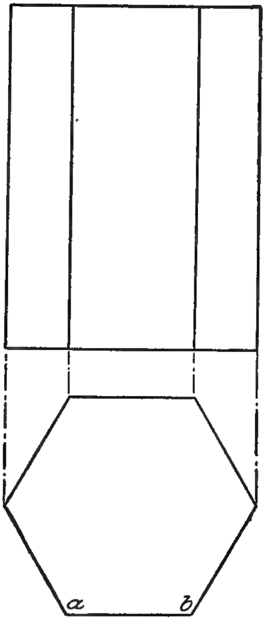

Fig. 9

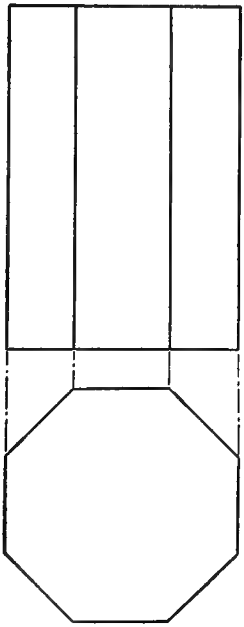

Fig. 10

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Exercise I	Title	Sheet IV

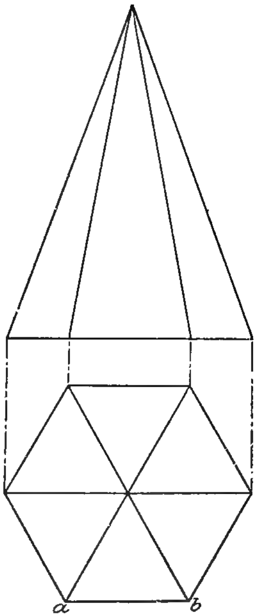

Fig. 11

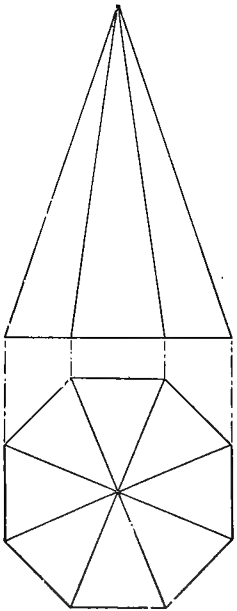

Fig. 12

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EXERCISE II

5. Exercise II consists of six sheets, each presenting three views of a geometrical solid. Two of these views must be drawn according to instructions in order to find the third one. Each sheet, as before, will be 9″ × 12″ with a working space of 8″ × 11″ inside the border line, and all sheets will be placed horizontally. The line *A B* through the center of the sheet will mark the division between the vertical and horizontal projections, and the elevations should be arranged to rest on this line.

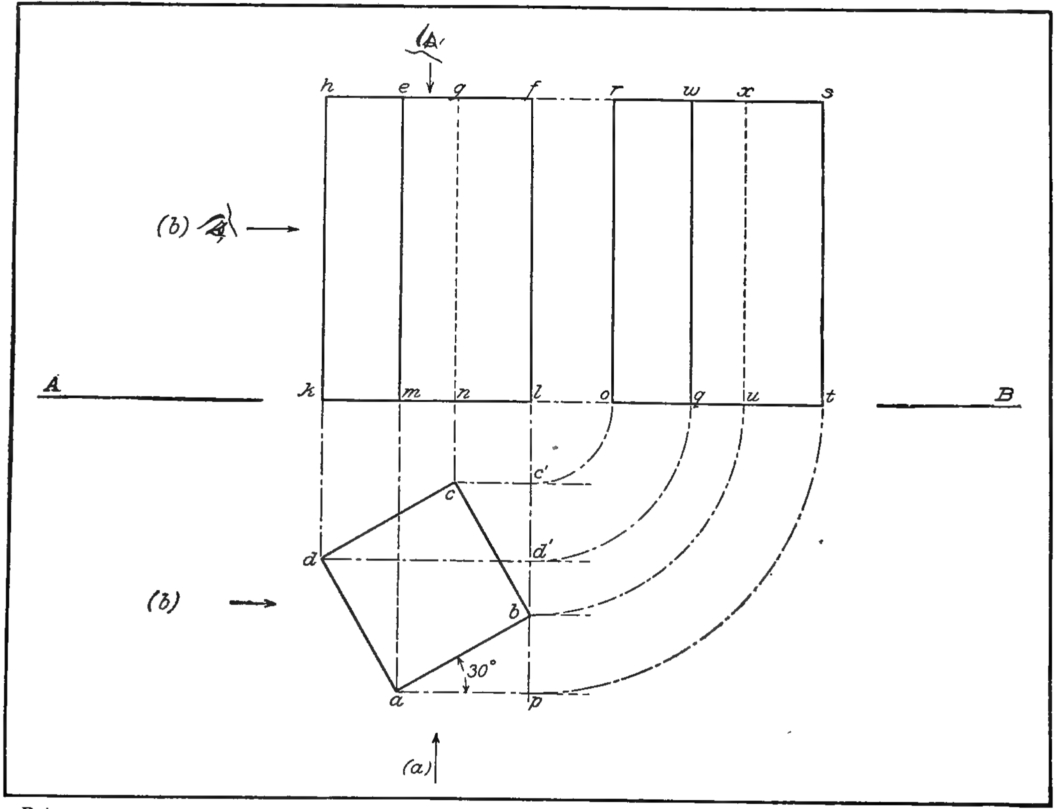
Problem 13. Exercise II, Sheet I.—The figure on Sheet I, Exercise II, is a rectangular prism $1\frac{5}{8}''$ square on the base and $3\frac{1}{4}''$ high. First draw the plan (*a*) locating the point *a* about $1\frac{1}{4}''$ above the lower border line, and 4″ to the right of the side border line. *a b*, $1\frac{5}{8}''$ long, is then drawn at an angle of 30° with the horizontal as shown. With the 30° and 60° triangle, the plan of the prism *a b c d* should then be drawn, and lines from its corners projected into the vertical plane, as shown at *k h*, *m e*, *l f*, etc. The height $3\frac{1}{4}''$ is then laid off from *k* to *h*, and the line *h f* drawn as shown.

The views of the prism are taken in the directions of the arrows shown, and therefore, in the elevation, the entire thickness of the prism is between the eye and the corner *c*, viewed as indicated in the plan by the arrow (*a*). Hence, the corner *c* is hidden and shown by a dotted line *n g* in the elevation. The other elevation of the prism *o r s t* is a view taken in the direction of the arrows (*b*) at the side of the elevation and the plan. To draw this, the points *d*, *c*, *a*, and *b* should be projected horizontally to the line *p l*, or any other vertical line conveniently located. Then where this line intersects with the line *k t* (which in this case happens to be at *l*), a center is taken and arcs are drawn as from *c′* to *o*, *d′* to *q*, *b* to *u*, and *p* to *t*. Vertical lines drawn through the points *o*, *q*, *u*, and *t*, and horizontal lines drawn on a level with the top and bottom of

Exercise II

Title

Sheet I



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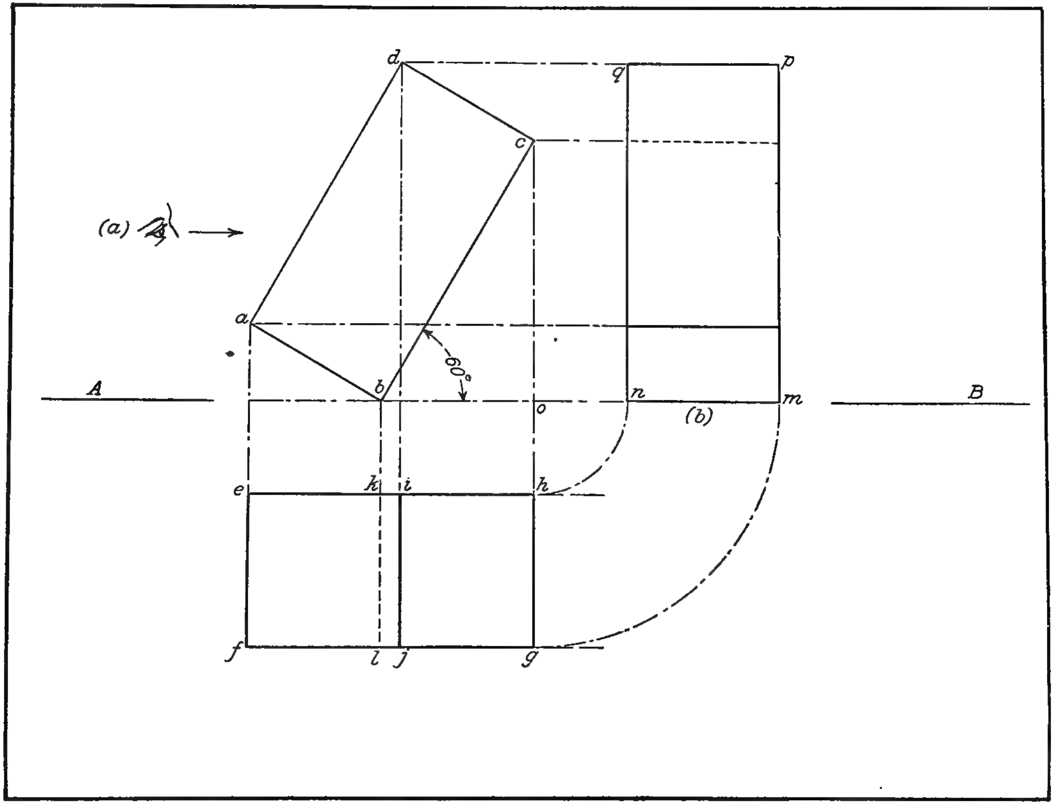
Name of Student, Class Letters and Number

the prism in the previous elevation, limit the form of this figure. The view being taken from the side of the plan as shown by the arrow, the point *d* is in full view and is shown by the vertical line *q w* in the side elevation, whereas the point *b* is on the back or further side of the prism and is therefore invisible and appears in the side elevation as a dotted line *u x*. The peculiarity of this problem is that the front elevation and side elevation are precisely alike; as a matter of fact, the side elevation is unnecessary, because one can determine from the plan exactly what the form and proportions of the figure are.

6. PROBLEM 14. Exercise II, Sheet II.—A different state of affairs exists in Problem 14, however, which is another view of this same prism in which the elevation is inclined, and the plan is parallel with the horizontal line *A B* through the center of the plate. The problem here is to find the side elevation. Draw the front elevation *a b c d* with its lower corner *b* resting on the horizontal center line, and $1\frac{5}{8}''$ to the left of the vertical center line. The sides *d a* and *c b* are inclined at an angle of 60° with *A B*, and the whole elevation is equal in dimension to the width and height of the prism on Sheet I, Exercise II; that is, the width *a b*, Sheet I, is the same as *a b*, Sheet II; and the height *k h*, Sheet I, is equal to *a d*, Sheet II. The side *e f* of the plan is then laid out to its proper dimension, $1\frac{5}{8}''$ long, *f* being immediately under *a* of the elevation, and $1\frac{1}{2}''$ above the lower border line. Horizontal lines *f g* and *e h* are drawn from *e f* indefinitely to the right. A perpendicular line from the corner *c* intersects these horizontal lines at *h* and *g* and limits the length of the prism in plan to *e h*, while a perpendicular line drawn from *d* shows the amount of surface at the top that can be seen by looking down at the prism and determines the size of the rectangle representing this top *h i j g*. The line from *b* gives the position of the lower corner as seen in the plan at *k l*, but this corner is dotted; for in looking down on the prism the entire solid is between the point *b* and the eye; therefore, *k l* is dotted. Draw a horizontal line from *b* toward *m*, and where this

Exercise II Title Sheet II



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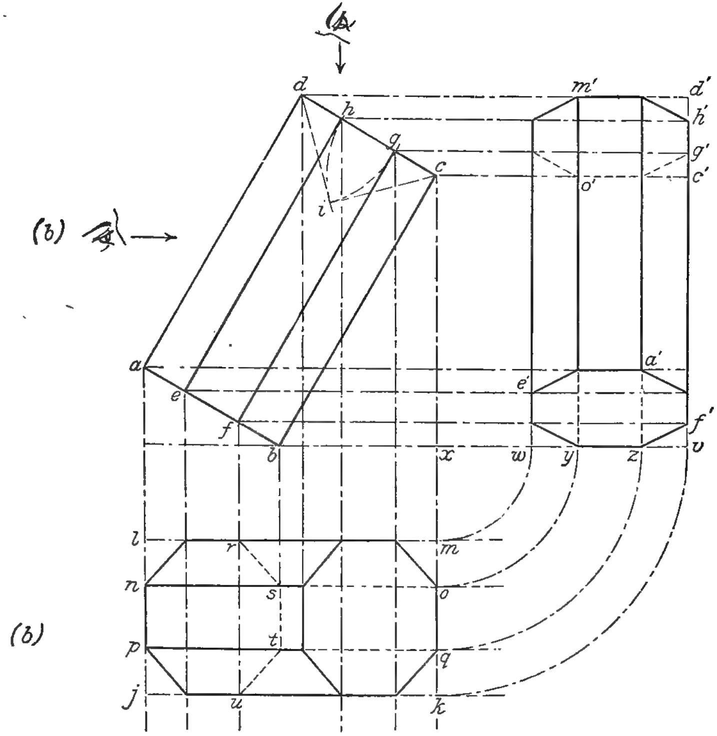
Exercise II　　Title　　Sheet III



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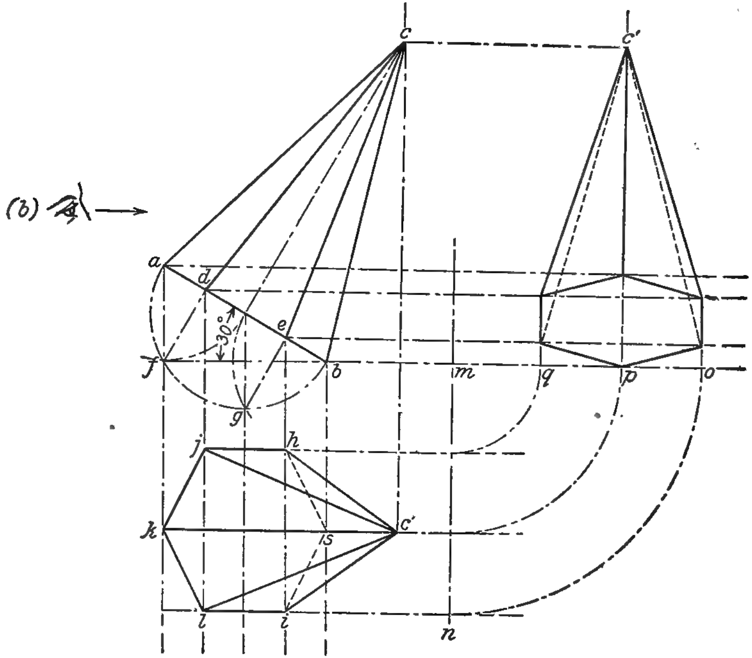
line intersects with *ch*, as at *o*, take a center and draw the arcs *hn* and *gm*. Vertical lines *mp* and *nq* mark the thickness of the prism as seen from the direction shown at the arrow (*a*). The corner *c* is shown in the side elevation (*b*) by a dotted line, while the corner *a* being near the eye and having nothing to obstruct it from view, is shown by a full line. Therefore, in these three drawings, we have three views of a simple solid, a combination of which gives not only its form but its actual position in space. It will be observed here that neither plan nor side elevation could have been drawn correctly without first drawing the front elevation; and while neither the plan nor side elevation show the angle to which the front elevation was inclined, nor a true length of its side, they may be placed in their proper positions and projection lines drawn so as to construct the front elevation and thereby show these proper dimensions. From this, we discover that if any two of these three views of an object—plan, front elevation, and side elevation—be given, we can place them in their respective positions and construct the third view.

7. PROBLEM 15. Exercise II, Sheet III.—Problem 15 is identical in character with Problem 14, except that the object is an octagonal prism instead of a square one. The elevation on Sheet III, Exercise II, consists of a prism $1\frac{5}{8}''$ in diameter, inclined at the same angle, 60°, as the prism in Sheet II, with its dimensions *ab*, *cd*, etc., similar to those in Sheet II. The position of the lines *fg* and *eh*, however, can be found by applying principles given in *Geometrical Drawing* at the upper end *cd* as follows: From the points *c* and *d*, diagonals are drawn at an angle of 45° with *cd* intersecting at *i*. Then, with *c* and *d* as centers and *ci* as a radius, arcs are drawn intersecting *cd* at *h* and *g*, thus locating the points from which *he* and *gf* may be drawn completing the elevation of the prism. Vertical lines should now be dropped from each of the points *a*, *e*, *f*, *b* and *d*, *h*, *g*, *c*, indefinitely, toward *jk*. The horizontal lines *lm*, *no*, *pq*, and *jk* should be drawn spaced from *l* to *m* to *k*

Exercise II

Title

Sheet IV



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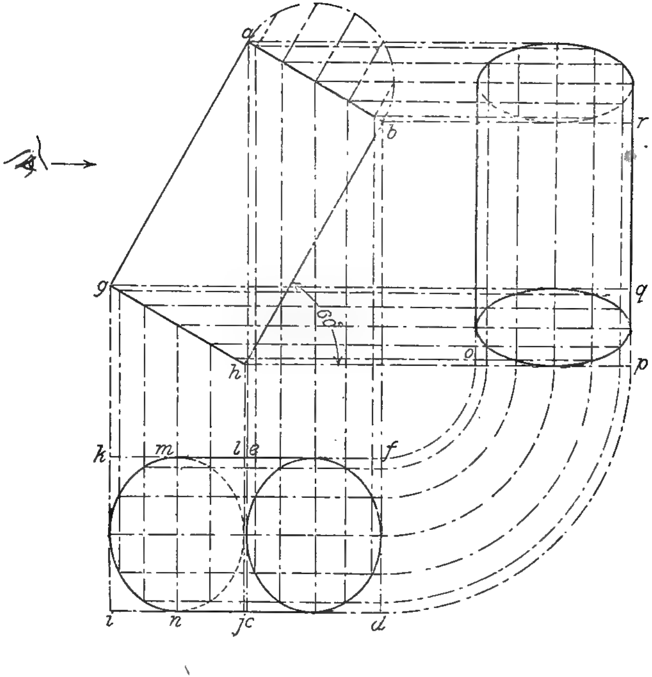
to *j*, similarly to the spacing of *a* to *e* to *f* to *b* in the elevation, as these represent the angles on the sides of the octagonal prism. At the points where the vertical lines from *d*, *h*, *g*, and *c* intersect, the horizontal lines through *m*, *o*, *q*, and *k*, the lines of the octagon determining the top of the prism may be drawn; whereas, where the lines from *a*, *e*, *f*, and *b* intersect the lines through *l*, *n*, *p*, and *j*, the outlines of the base of the prism may be drawn. As the sides of the prism from *f* to *b* are beneath the entire solid, they are shown in the plan dotted, as at *r*, *s*, *t*, *u*. Now, with a center at *x* where the line *c k* intersects the line *b v*, the arcs *m w*, *o y*, *q z*, and *k v* are drawn. The vertical lines through the points so located represent the side of the octagon as it appears when viewed in the direction of the arrow (*b*) in the front elevation. The widths of the details at the top are determined by the width marked off at *w*, *y*, *z*, and *v*; whereas, the heights, as shown by the foreshortenings, are determined by the spaces between lines *d d'*, *h h'*, *g g'*, and *c c'*. The surface *e' a' f' z y* shows the bottom of the prism and is drawn entirely in full lines; while the surface *m' h' g' o'* representing the top of the prism is drawn with the more distant side dotted, as the entire solid intervenes between this side and the eye.

When a surface is inclined away from the eye, as is the base of this prism in the front elevation, its projection in the side elevation is said to be *foreshortened*, as it appears shorter or narrower than it really is. Thus, the octagonal base and top of the prism, as shown in the plan and side elevations, are foreshortened because they do not show their true dimensions in that position.

8. PROBLEM 16. Exercise II, Sheet IV.—In Problem 16, we have a hexagonal pyramid, the elevation of which is inclined with its base *a b* at an angle of 30° with the horizon, as shown. The point *b* of the base should rest on the horizontal center line, $1\frac{1}{4}''$ to the left of the vertical center line. The width of the base from *a* to *b* is 2″, and its height to the apex *c* is $3\frac{1}{4}''$. To get the positions of the corners *d c* and *e c*, *Exercise II* *Title* *Sheet V*



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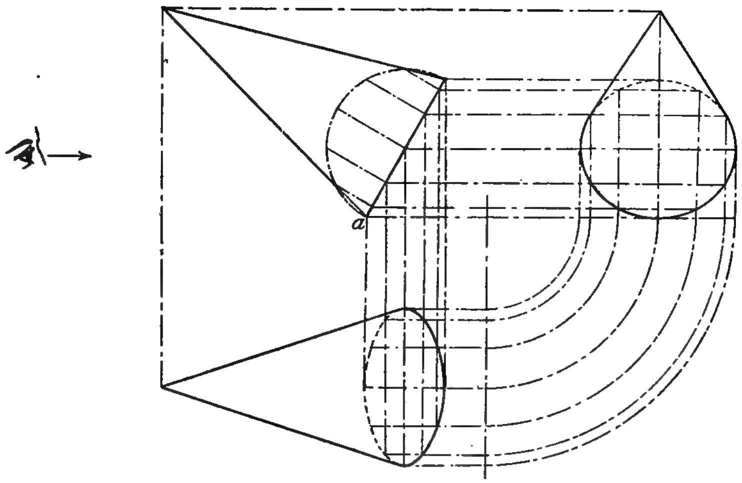
a semicircle should be drawn with the base *a b* as a diameter. The points *f* and *g* can be laid off on this semicircle with the radius of the semicircle subtending the arc as in the regular manner for drawing a hexagon within a circle. Lines drawn from *f* and *g* vertical to *a b* will locate the points *d* and *e*. Vertical lines through *a*, *d*, *e*, and *b* will establish points in the plan that will determine the outline of the base; while a vertical line through *c* will locate the apex in the plan at *c′*. In drawing the plan of the pyramid, note that the portion of the base that shows from *e* to *b* in the elevation is hidden when one looks down on it, and therefore appears in the plan dotted at *h s i*. The other side of the hexagonal pyramid *j k l* appears as a full line. The width of the plan *j l* is equal to the width of a hexagon inscribed in a circle whose diameter is equal to *a b*. The vertical line *m n* is now drawn at any point intersecting with the base line *f o*; and, with *m* as a center, arcs are drawn with radii taken from the points where the lines *f h*, *k c′*, and *l i* extended cut the vertical *m n*. Thus the points *o*, *p*, and *q* are located. These points correspond with the widths taken from the plan, whereas the height of each particular detail is projected across with the **T** square from the front elevation. Here, as in the case of the octagonal prism, the full base of the pyramid is shown and the sides *c b* and *c e* are shown dotted where the upturned base hides them from view.

9. PROBLEM 17. Exercise II, Sheet V.—Problems 17 and 18 are similar in principle to Problems 15 and 16, Problem 17 being a cylinder instead of a prism, and Problem 18 being a cone instead of a pyramid. To draw Problem 17, the elevation of the cylinder is drawn in exactly the same position as the elevation of the prism in Problem 15. The height of the cylinder is 3″, while its width is 1⅝″, the side *b h* being inclined at 60°. Point *h* rests on the horizontal center line, 1⅝″ to the left of the vertical center line. The shape and position of the top should be the first thing considered in drawing the plan, and therefore perpendicular lines should be dropped from *a* to *c* and from

Exercise II

Title

Sheet VI



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b to *d*, marking the projected width of the visible end of the prism. The width of the prism $1\frac{5}{8}''$ is now laid off from *d* to *f*, *f* being located 1″ below the horizontal center line. Lines being drawn forming the rectangle *c d f e*, we can draw within this rectangle an ellipse that will correspond to the foreshortened view of the top of the cylinder. Similarly, vertical lines dropped from *g* to *i* and *h* to *j* will form the rectangle *j i k l*, within which the lower surface of the cylinder, elliptic in shape, may be drawn. It will be observed that half the ellipse from *m* to *n* is shown dotted, as the solid of the cylinder is above it, thus preventing its appearing in full view. The side elevation of the cylinder is drawn by laying off the width *o p* and projecting the lines *g q* and *b r* to limit the depth of the ellipses that form the top and bottom. The lower ellipse, representing the bottom of the cylinder, is drawn in full; but the lower half of the upper ellipse, being hidden from view, is dotted.

PROBLEM 18. Exercise II, Sheet VI.—Problem 18 consists of a cone whose base is $1\frac{5}{8}''$ in diameter and whose height is 3″. This cone can be inclined at any convenient angle, and the corner *a* should be on the horizontal center line, 1″ to the left of the vertical center line. Work out this problem on precisely the same lines as Problems 15, 16, and 17 were worked, showing all the construction lines and how each point was located.

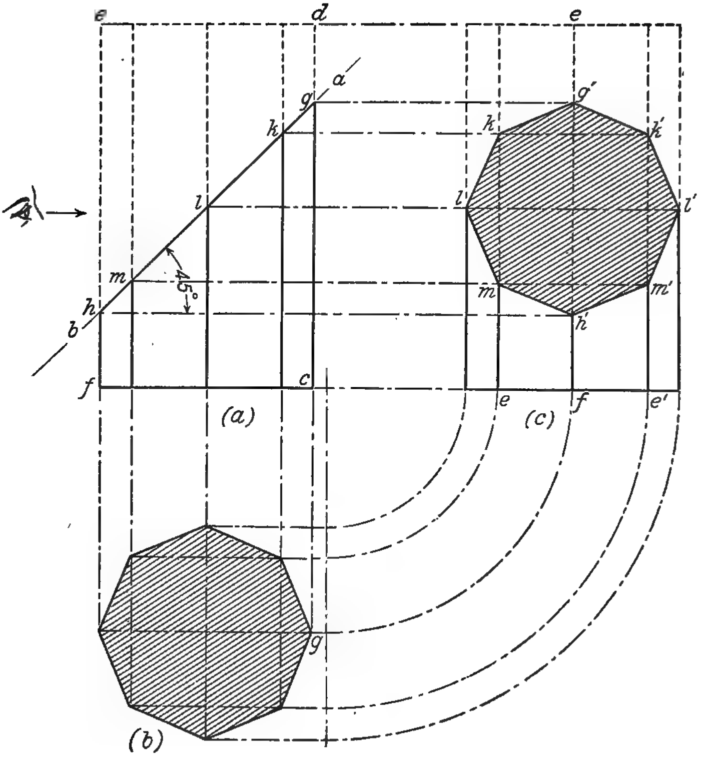
In working these problems in projections, do not at any time copy from the exercise any line of which the meaning is not understood, as such copying is a waste of time and is likely to cause serious difficulty in future work. These problems are explained as clearly as possible, but if there is any individual difficulty experienced write for further information after having tried diligently to work it out. These are not exercises in drawing, although we require them to be drawn accurately and neatly; they are problems in mathematics that one must be able to solve whenever they occur in regular practice, and the simple copying of these figures without any attempt to study the principle involved will do no good. Always know why certain lines are full lines and other lines are dotted lines. By trial, it should be possible to draw any rectangular object in any position it may be placed so that a combination of its three views will express conclusively what that drawing stands for. In making drawings of cylinders and cones, it is sometimes advisable to consider them prisms or pyramids and work them out as figures having a polygon for a base with a large number of sides. After the various angles of the bases are then projected, it is a simple matter to sketch in the ellipses circumscribing the polygonal bases, thus forming the bases of the cones and cylinders accurately to scale. After finishing the problems in Exercise II, carefully letter the title PROJECTIONS, etc. at the top and the usual matter at the bottom of each sheet and send them in for correction.

SECTIONS

EXERCISE III

10. Exercise III consists of four sheets, each containing one figure. The drawings are arranged on the individual sheets as before, by drawing a horizontal and a vertical center line, and starting the work from these lines. This exercise consists of the projection of four geometrical solids: an octagonal prism, a cylinder, an octagonal pyramid, and a cone. Each solid being cut by a plane *a b*, the purpose of this exercise is to demonstrate how to obtain the front or side elevation and plan of the surface of the cutting plane where it passes through the solid. For instance, in Sheet I, we have the elevation of the octagonal prism at *c d e f*, the plane *a b* that passes through it entering one corner *g* and passing out the other corner *h*. The corner of the prism where the plane *a b* first enters is shown in the front elevation (*a*) at *c d* in the plan at *g*, and in the side elevation at *e f*.

PROBLEM 19. Exercise III, Sheet I.—Draw the plan of the prism as an octagon whose center is 2½″ below and 1½″ to the left of the horizontal and vertical center lines, respectively. Draw the elevations (*a*) and (*c*) 3¾″ high and resting on the



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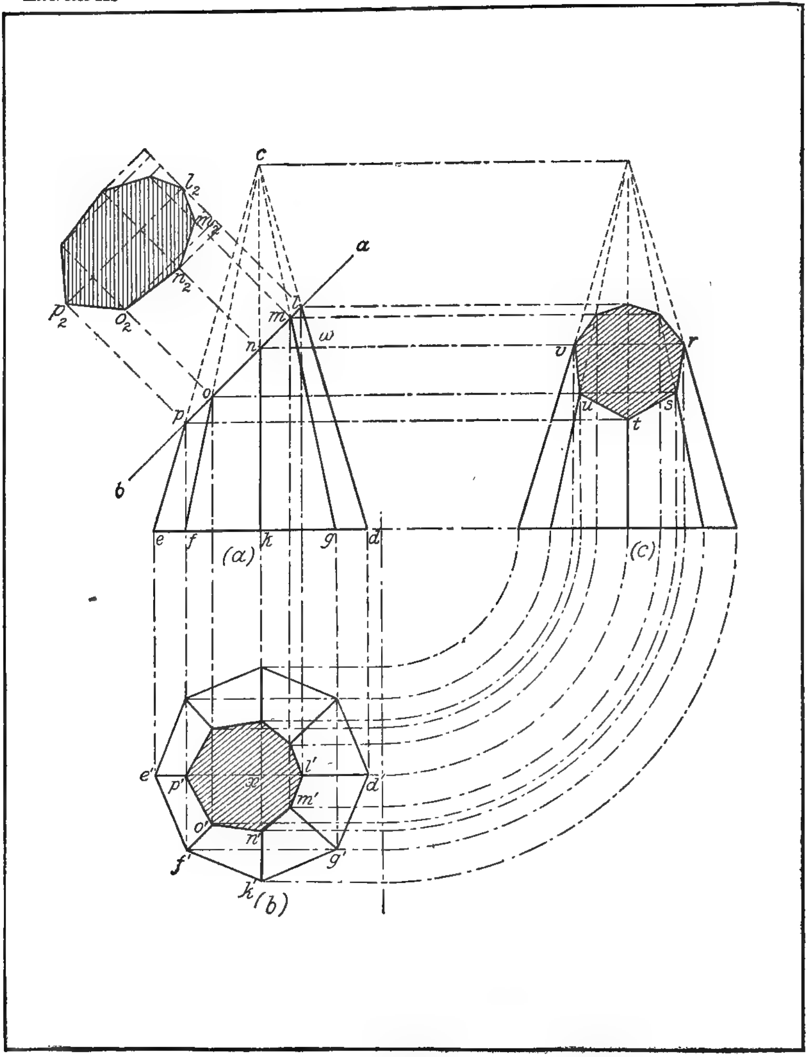
horizontal center line of the sheet. Now draw the plane *a b* at an angle of 45° cutting both sides of the prism as shown, Exercise III, Sheet I.

Where this plane passes through the successive elements or corners of the prism, as at *g*, *k*, *l*, *m*, and *h*, in the elevation (*a*), project horizontal lines until these lines intersect with the same elements in the elevation (*c*). The line *e f* in the front elevation (*a*) being the same as the line *e f* in the side elevation (*c*), we have, in (*c*), at *g'*, the upper point of the intersection, and at *h'* the lower point of the intersection of the plane with the prism; whereas, at *k* and *k'* we have the intersection of a line from *k*, in the elevation (*a*), with the elements of the prism *e k* and *e' k'*, the other points of intersection where the passing plane intersects the elements of the prism. Connecting the points *g'*, *k'*, *l'*, *m'*, *h'*, *m*, *l*, and *k* by straight lines, presents the elevation of the truncated prism below the cutting plane *a b*. The surface of the section in this case happens to be a regular octagon, in elevation, because the plane *a b* is at an angle of 45°. The proportions of the plane of intersection will vary according to the angle of the cutting plane.

11. PROBLEM 20. Exercise III, Sheet II.—Problem 20 is similar to Problem 19 except that a pyramid is involved instead of a prism. Draw the center line of the plan and elevation $1\frac{1}{2}''$ to the left of the vertical center line of the sheet and locate the center of the plan $2\frac{1}{2}''$ below the horizontal center line. The outline of the plan of this figure is precisely the same as the outline of the plan in Problem 19. The elements, or corners, of the pyramid, however, show in the plan (*b*) as far as they exist below the cutting plane *a b*, and the plane of the upper surface of the truncated pyramid appears as an irregular octagon. Draw the octagonal plan (*b*) and the two elevations (*a*) and (*c*), the complete diameter of the base being about $2\frac{1}{4}''$ and the altitude of the elevation $3\frac{3}{4}''$. Draw the cutting plane *a b* at an angle of 45° with the axis of the pyramid. Where this plane intersects the elements of the cone *d c*, *g c*, *k c*, etc., let fall

Exercise III *Title* *Sheet II*



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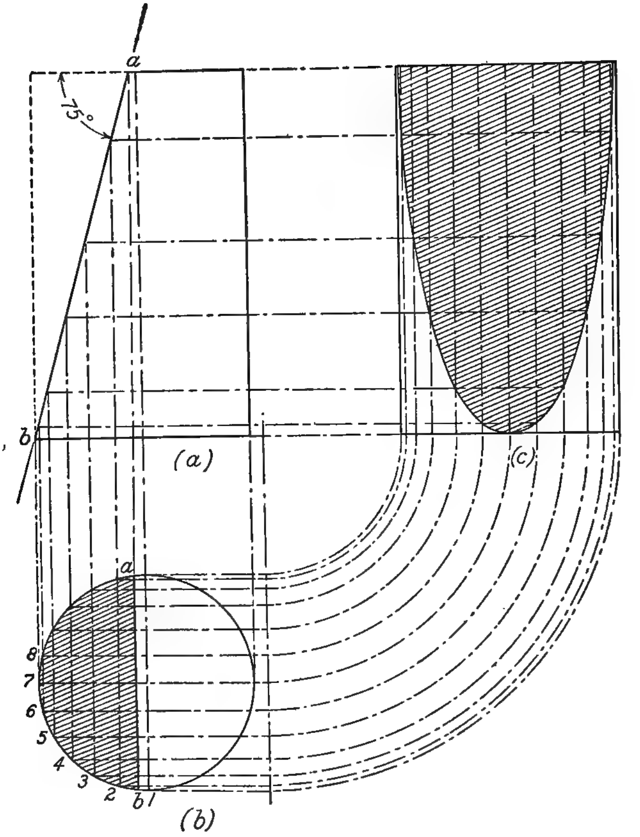
perpendicular lines until they intersect the same elements represented in the plan as *d′ x*, *g′ x*, *k′ x*, etc. Connecting these points of intersection presents the plan of the section cut by the plane *a b*. This plan should be an irregular octagon, as shown at *l′*, *m′*, *n′*, *o′*, *p′*, etc. To show the width of the section in the plan taken through the radial line *k n* of the elevation and its corresponding opposite edge, simply transfer the distance *n w* from the elevation and locate it in the plan on either side of *x*, as at *x n′*. The side elevation (*c*) is now drawn by projecting lines from the points *l*, *m*, *n*, *o*, *p* to intersect with the same elements represented in elevation (*c*); the outline of the surface of intersection can now be drawn as shown at *r s t u*, etc., Exercise III, Sheet II.

12. PROBLEM 21. Exercise III, Sheet III.—In Problem 21 is a cylinder that involves the same principles as found in Problem 19, except that the plan is a circle and the elevation a rectangle. The plan of this cylinder is a circle $2\frac{1}{4}''$ in diameter and its center is $1\frac{3}{4}''$ to the left of the vertical center line, and $2\frac{1}{2}''$ below the horizontal center line. The elevation is located on the horizontal center line, and is $3\frac{3}{4}''$ high. The cutting plane *a b* does not pass through both the top and bottom of the solid, but enters the top slightly to the left of the center at *a* and passes out at the lower left side, tangent to the circular base at *b*. This cutting plane *a b* is drawn at an angle of 75°, as shown in Exercise III, Sheet III (by a combination of the 45° and the 30° triangles). The side of the cylinder may now be considered as divided into a number of parts, and a vertical line through each part represents an element in the surface of the cylinder. For convenience, the circumference of the plan of the cylinder is divided into twenty-four parts, as *1*, *2*, *3*, *4*, etc. This can be readily done by a combination of the 60°, 30°, and 45° triangles. Lines from these points of division are projected through both elevations, as shown, and from the points where these lines intersect the line of the plane *a b*, in elevation (*a*), horizontal lines are drawn until they intersect, in the elevation (*c*), lines representing similar elements to those in (*a*).

Exercise III

Title

Sheet III



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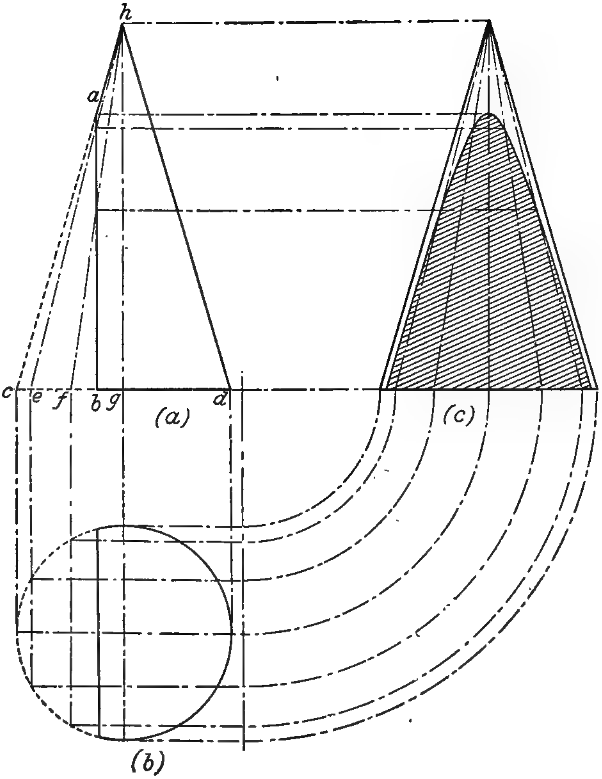
These points of intersection, connected with a curved line will represent the outline of the surface of the plane cutting through the cylinder.

13. Problem 22. Exercise III, Sheet IV.—Problem 22 is similar to Problem 21, except that the cutting plane *a b* is vertical, and passes through a cone so as to cut the base well toward the center. The cone is $2\frac{1}{4}''$ in diameter at the base and $3\frac{3}{4}''$ in altitude. To draw this figure, locate the center of the plan (*b*) $1\frac{3}{4}''$ to the left of the vertical center line and $2\frac{1}{2}''$ below the horizontal center line; and on the horizontal center line draw the two elevations in the usual manner. Divide the circumference of the base into twelve equal parts with a 60° and 30° triangle. Project lines from these parts until they intersect the base of the cone in the elevation (*a*). From the points of intersection *c*, *e*, *f*, etc., to the vertex of the cone, draw lines *e h*, *f h*, etc. and consider each as an element of the cone. Where the cutting plane intersects one of these elements, draw a horizontal line until it intersects a similarly drawn element in the elevation (*c*). This similar element can be determined by following from the point of intersection in elevation (*a*) down to the base of the cone, vertically to the plan, and around the quarter circle (*c*). The points located on (*c*) can now be connected by a curved line; the surface will be a hyperbola and will appear in full and true dimensions. The projections of the cutting surfaces in Problems 19, 20, and 21, however, are inclined away from the eye at the same angle that the cutting plane is; therefore, they are foreshortened and do not present their true dimensions in the elevation. In order to accomplish these true dimensions it is necessary to proceed as follows:

On Sheet II where the cutting plane *a b* intersects the elements of the pyramid at *l*, *m*, *n*, *o*, and *p*, lines are drawn perpendicular to *a b*, as $l\,l_2$, $m\,m_2$, $n\,n_2$, etc., and $l_2\,p_2$ is drawn at any convenient point parallel to *a b*. Then, from the plan (*b*) the widths are laid off each side of l_2, p_2 as a center line. Thus, the distances from the line $e'\,d'$ in the plan (*b*) to the points $m'\,n'\,o'$ and p' are laid off above and

Exercise III *Title* *Sheet IV*



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below l_2p_2 in the elevation (*a*) as shown at $m_2n_2o_2$ and p_2. These points, being connected up by straight lines, outline an irregular octagonal surface showing the true form of the upper side of the pyramid as cut by the plane *a b*.

If the solid were a cone, the process would be the same, except in connecting the various points so located a continuous curved line would be used, thereby presenting a parabola, hyperbola, or an ellipse, according to the position of the cutting plane. The title of this exercise SECTIONS should be carefully placed at the center of the top of each sheet, and the other lettering in the usual places and all four sheets mailed FLAT at one time for correction.

INTERSECTIONS

EXERCISE IV

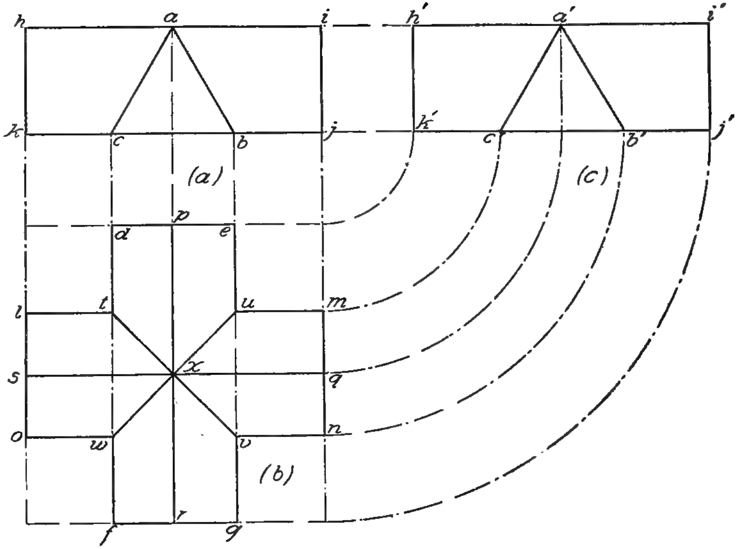
14. The six sheets for Exercise IV contain one figure each, and may be laid out by the method of vertical and horizontal center lines, as explained for previous exercises. This exercise consists of six problems in the intersections of solids. Sheet I shows the intersections of two triangular prisms of the same size and Sheet II the intersection of two triangular prisms of different sizes. Sheet III shows the intersection of two irregular pentagonal prisms and Sheet IV the intersection of an irregular pentagonal prism with a triangular prism. Sheet V shows the intersection of two semicylinders of equal diameters, while Sheet VI shows the intersection of two semicylinders of different diameters. The purpose of these six problems is to illustrate methods by which the lines of intersection of any two slopes may be obtained, and at the same time to present geometrical solids as illustrations that will conform as nearly as possible to actual architectural and design problems that may arise.

PROBLEM 23. Exercise IV, Sheet I.—To draw Exercise IV, Sheet I, commence by laying out the end elevation

Exercise IV

Title

Sheet I



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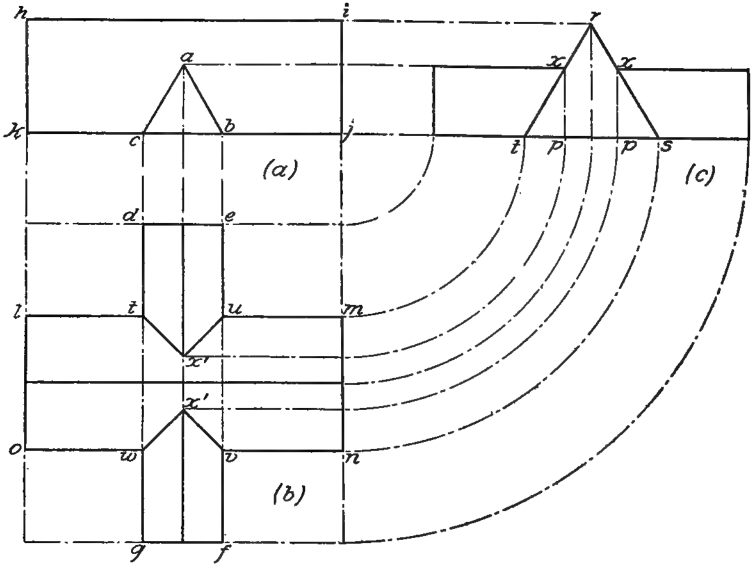
of the triangular prism *a b c*, its point *a* being 2″ to the left of the vertical center line, and 2½″ above the horizontal center line. The sides of the prism are 1¼″ each and the angles each 60°. The plan of this prism *d e f g* is then drawn below the base *c b* as shown, the length *d f* being 3″. The side elevation of the other prism *h i j k* is then drawn as shown, the length *h i* being 3″; the plan of the second prism is shown at *l m n o*. It will be observed in the plan that the upper edges of the prisms *s q* and *p r* intersect at the point *x*, while the lower edges of the prism *d f*, *l m*, etc. intersect at the points *t*, *u*, *v*, *w*. Therefore, lines drawn from *t*, *u*, *v*, and *w* to where the upper edges intersect will be the lines of intersection, as shown at *t v* and *u w*. The elevation (*c*) is precisely the same as the elevation (*a*); but in this case, the triangle *a′ b′ c′* represents the end view of the prism *h i j k* in (*a*), and the rectangle *h′ i′ j′ k′* in (*c*) represents a side elevation of the prism *a b c* in (*a*). It will appear from this that when two prisms whose sides incline at equal angles intersect each other at right angles, the lines of intersection will be at 45° with the axes of the prisms. Thus, in (*b*), we have two triangular prisms whose sections contain similar angles; therefore, the lines of intersection *t v* and *u w* are at 45° with the axes of the prisms.

15. Problem 24.—In Problem 24, the same process is carried out except that the two prisms are of different sizes. Here the elevation of one prism *a b c* is drawn with the point *a* 2″ to the left of the vertical center line, and 2¼″ above the horizontal center line. The sides *a b*, *b c*, and *c a* are each ¾″. The plan of this prism is then drawn as shown at *d e f g*, the side *e f* being 3″ long. The side elevation of the other prism *h i j k* is then drawn as at (*a*), the side *h i* being 3⅛″ long; the plan of this prism is shown at *l m n o*. In (*c*) the end elevation of the larger prism and the side elevation of the smaller prism is drawn, the sides *r s*, *s t*, and *t r* being 1¼″ each. The points *x* show how high the smaller prisms extend on the larger. This point, being carried down to the base line of the prism at *p* and swung into the

Exercise IV *Title* *Sheet II*



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plan, with point j of (a) as a center, gives the point x' in the plan (b), which is the point where the upper edge of the smaller prism intersects the side of the larger prism. Lines from t, u, v, and w, where the base line intersects, to the points x' in the plan, give the lines of intersection in the plan. These lines of intersection, as in the previous problem are at an angle of 45° with the axis of the prism, because both prisms have the same slope or angles.

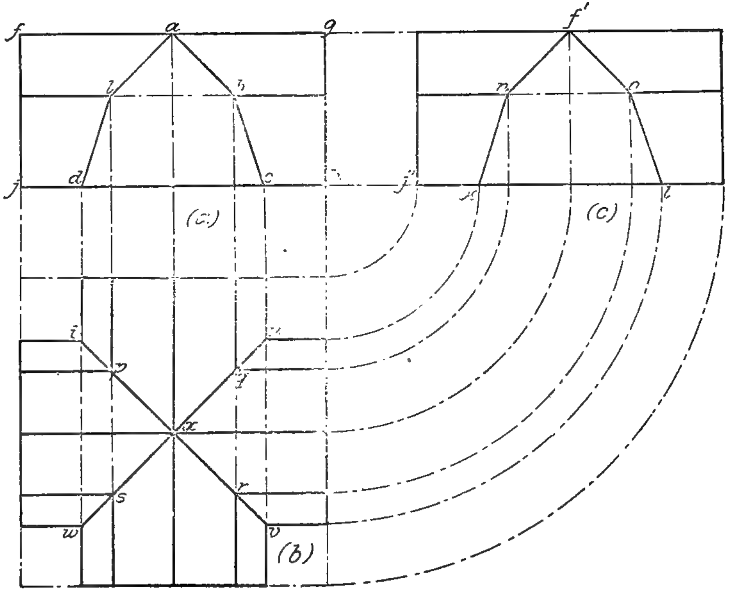
16. Problem 25. Exercise IV, Sheet III.—Problem 25 is precisely the same as the two preceding, except that it contains two irregular pentagons. Commence by drawing the pentagon $a\,b\,c\,d\,l$ with its point a $2''$ to the left of the vertical center line and $2\frac{3}{4}''$ above the horizontal center line. The base $d\,c$ is $1\frac{7}{8}''$ long; and the distance $l\,b$ is $1\frac{5}{16}''$. The sides $l\,a$ and $b\,a$ are inclined at angles of 45°. The side elevation of the other prism at $g\,h\,j\,f$ is $3''$ long and $1\frac{1}{2}''$ high from j to f, and the lines of intersection, as shown in (c), are precisely the same as those of the previous problems. The side elevation of (c) is similar to (a) and the distance $h\,j'$ between them is $1''$. In drawing the plans of these two prisms, lines are projected from the front elevation (a) and side elevation (c), as shown in the exercise; the points of intersection of lines from d and c in the elevation (a) and from k and l in elevation (c) when projected into the plan (b) locate the intersection of the bases at t, u, v, w. The intersection of the upper edges or angles occurs in the plan (b) at x, as may be seen, and the intersection points l and b in (a) and of n and o in (c) occur in the plan (b) at $p\,q\,r\,s$. Lines drawn through u and t to w and v, therefore, give the lines of intersection, and again we find that these lines are at an angle of 45° with the axes of the prisms, as both intersecting slopes are at the same angle.

17. Problem 26. Exercise IV. Sheet IV.—In Problem 26, we have the intersection of a pentagonal prism similar to that in Exercise IV, Sheet III, with a triangular prism similar to that in Sheet I. It will be here observed, on looking at the plan (b), that the lines are no longer at an angle of 45°

Exercise IV

Title

Sheet III



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Exercise IV

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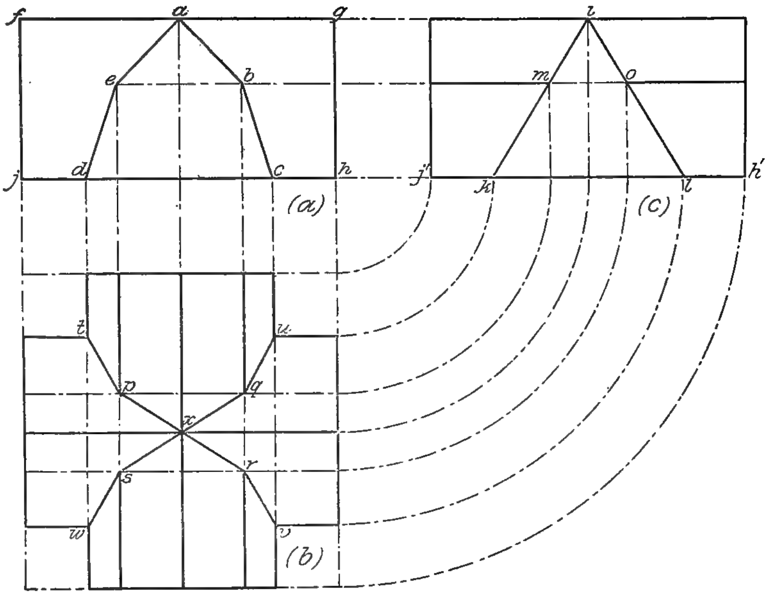
Sheet IV



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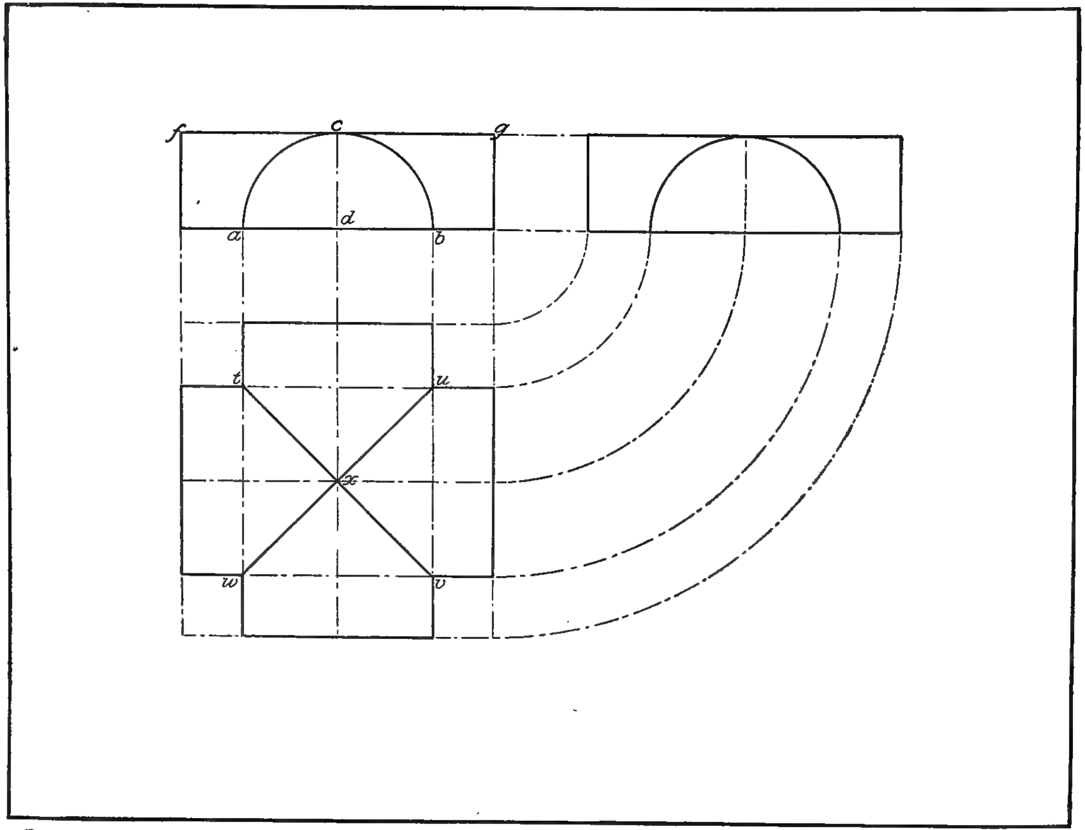
owing to the fact that the slopes of the triangular prism are different from those of the pentagonal prism. The elevation (*a*) is similar to that in Sheet III (*a*), the point *a* being 2″ to the left of the vertical center line and 2¾″ above the horizontal center line. The line *fg* is 3″ long. In the elevation (*c*), we have the end view of the triangular prism and the side view of the pentagonal prism. The sides *ik*, *il*, and *kl* of the triangular prism are 1¾″ long; the lengths *j′h′* and *jh* are 3″ each; and points *h* and *j′* are 1″ apart. When the plan (*b*) is drawn, it is found that the upper edge of the triangular prism and the upper edge of the pentagonal prism intersect at *x*, whereas the bases of the two prisms intersect at *t*, *u*, *v*, and *w*. In (*c*), the edges of the pentagonal prism intersect the sides of the triangular prism at *m* and *o*, and swinging these points around into the plan (*b*) (with a center at *h*), we find that they intersect with the projected lines from *e* and *b* in (*a*) at *p*, *q*, *r*, and *s* in (*b*). Lines drawn from *t*, *u*, *v*, and *w* to *p*, *q*, *r*, and *s* give in the plan the lines of intersection of the lower slopes of the pentagonal prism, *bc* and *ed* of (*a*) with the triangular prism; and lines drawn from *p*, *q*, *r*, and *s* to the point *x* give the lines of intersection of the slopes *ab* and *ae* in (*a*) with the triangular prism, thus completing the intersection as it shows in plan.

18. Problem 27. Exercise IV, Sheet V.—In Problems 27 and 28, the principles are identical to those in Problems 23 and 24, except that the solids are semicylinders instead of prisms. The diameter *ab* of the cylinder is 2″ and the center *d* is located 2″ to the left of the vertical center line and 1⅞″ above the horizontal center line. The length of the intersecting cylinder *fg* is 3″ and in plan we have the points *t*, *u*, *v*, and *w* where the lower edges intersect. The lines of intersection *uw* and *tv* are at an angle of 45° with the axis of the cylinders because the curvature of each is the same, namely, that of a circle. Had one of these been an ellipse and the other one a circle, the line of intersection would have been irregular; but since they are both arcs of circles or both arcs of the same ellipse, the lines of intersection will be at 45° with the axis.

Exercise IV *Title* *Sheet V*



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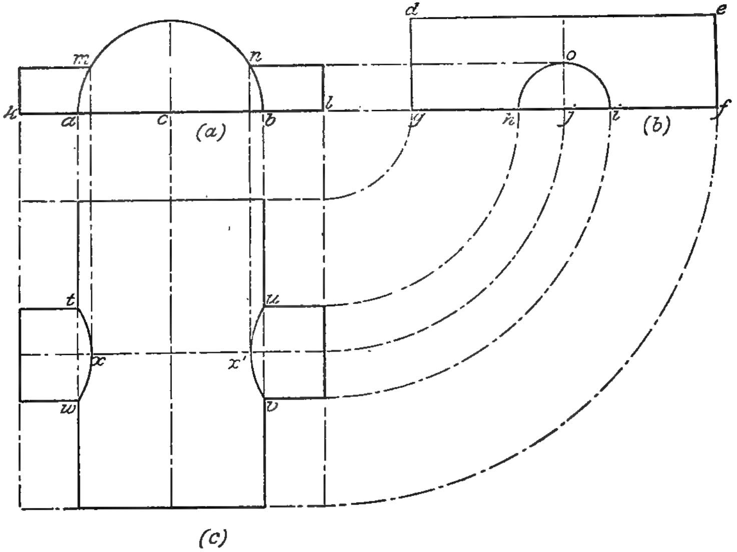
Exercise IV Title Sheet VI



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PROBLEM 28. Exercise IV, Sheet, VI.—This problem is similar to Problem 24. The diameter of the semicylinder *a b* is the same as in Exercise IV, Sheet V; the center is located as in Sheet V, and the side elevation *d e f g* is drawn to the right, the length *d e* being 3″. The smaller semicylinder *h i* is only $\frac{7}{8}$″ in diameter, and its center *j* is on the base and directly in the center of *g f*; *g* is 1″ to the right of *l*. The side elevation of the smaller cylinder *k l* in (*a*) is 3″ long. The plans of the two cylinders are now drawn at (*c*) and lines projected from the points *a* and *b* of (*a*) and *h* and *i* of (*b*) intersect at *t*, *u*, *v*, and *w*, of (*c*). Project lines from the top of the smaller cylinder *m* and *n* in (*a*) and *o* in (*b*) and they will intersect at *x* and *x′* in (*c*). The lines *t x*, *w x*, *u x′* and *v x′* are the lines of intersection of the two semicylinders. Each sheet of this exercise is to be lettered as were the previous sheets, with title (in this case INTERSECTIONS), exercise number, sheet number, etc., and all the sheets then sent to the Schools for correction.

These problems on projection drawing contain all the principles that will be required in ordinary architectural or design drawing. They will appear in different forms as the studies are continued, but the application of the principles of these simpler problems is all that will be required, and it is absolutely necessary that you should be thoroughly familiar with these applications and with every form of the problem herein set forth, as any misunderstandings will lead to further difficulty. Therefore, do not hesitate to ask for any information in connection with these projections and intersections, relative to points that are not clearly understood.

DEVELOPMENTS

19. It is frequently necessary, in design work, to prepare a drawing that is to be worked out in some decorative medium or material to fit the curved or spherical surface, or to extend around an angle at the corner of a building or utensil. In order that all parts of the design may be harmonious and fit together properly, it is necessary that the design should be prepared on a flat surface that is equal in area and proportion to the curved or combined surfaces of the object it is to adorn. In order to accomplish this, we take the surface of our object and unroll it, or develop it, as it is termed, so that it lies out perfectly flat.

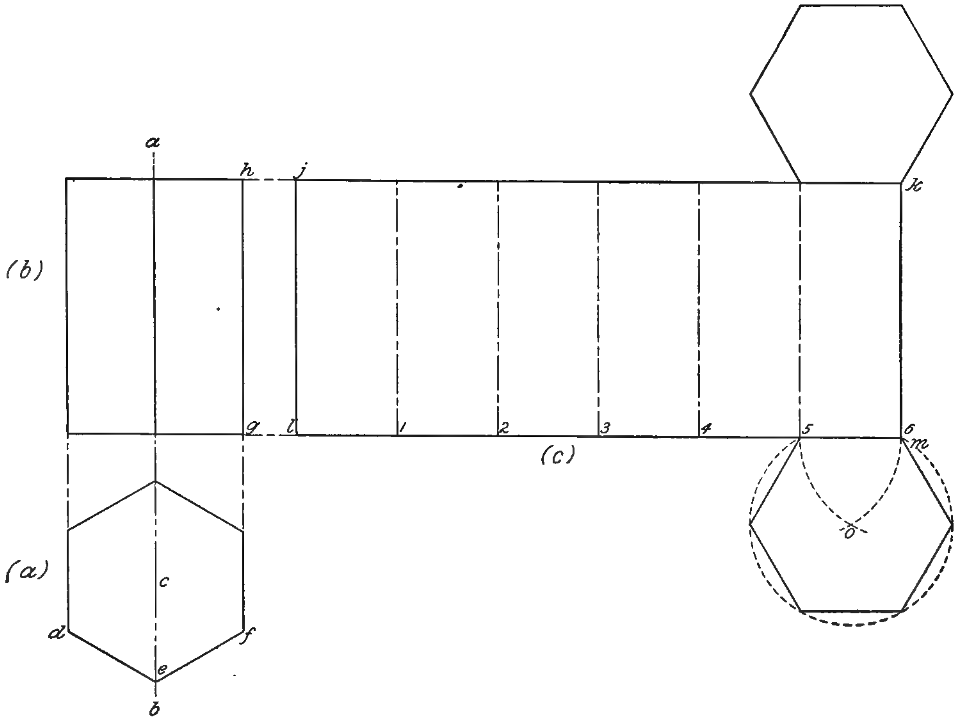
(*a*) and (*b*) on the first sheet of the exercise show the plan and elevation of a hexagonal prism, while at (*c*) is shown the development of its surface wherein each of its sides is shown as a single panel and at the end a hexagonal top and base. This form could be cut out of paper or sheet metal, folded on the vertical lines dividing the panels and horizontal lines separating the six panels from the top and bottom, and be bent into a perfect hexagonal prism of the form shown in plan of elevation at (*a*) and (*b*). The exercise on Developments will consist of four sheets, each 9″ × 12″ outside and 8″ × 11″ inside the border line.

20. Problem 29. Exercise V, Sheet I.—Turn the sheet horizontally and draw a vertical line *a b* 2″ to the right of the left border line; this will be the center line of the plan and elevation of the prism. 1½″ above the lower border line and on the center line *a b*, locate the center (*c*) of a circle 2″ in diameter, within which describe the hexagonal base *d e f*, etc. Project lines from *d* and *f* into the elevation, making the height of the prism *g h* 2½″. Draw indefinite lines *j k* and *l m* so that the distance *j l* will be equal to the height *h g*. Take any side of the hexagon, as *e f*, and with a pair of dividers

Exercise V

Title

Sheet I



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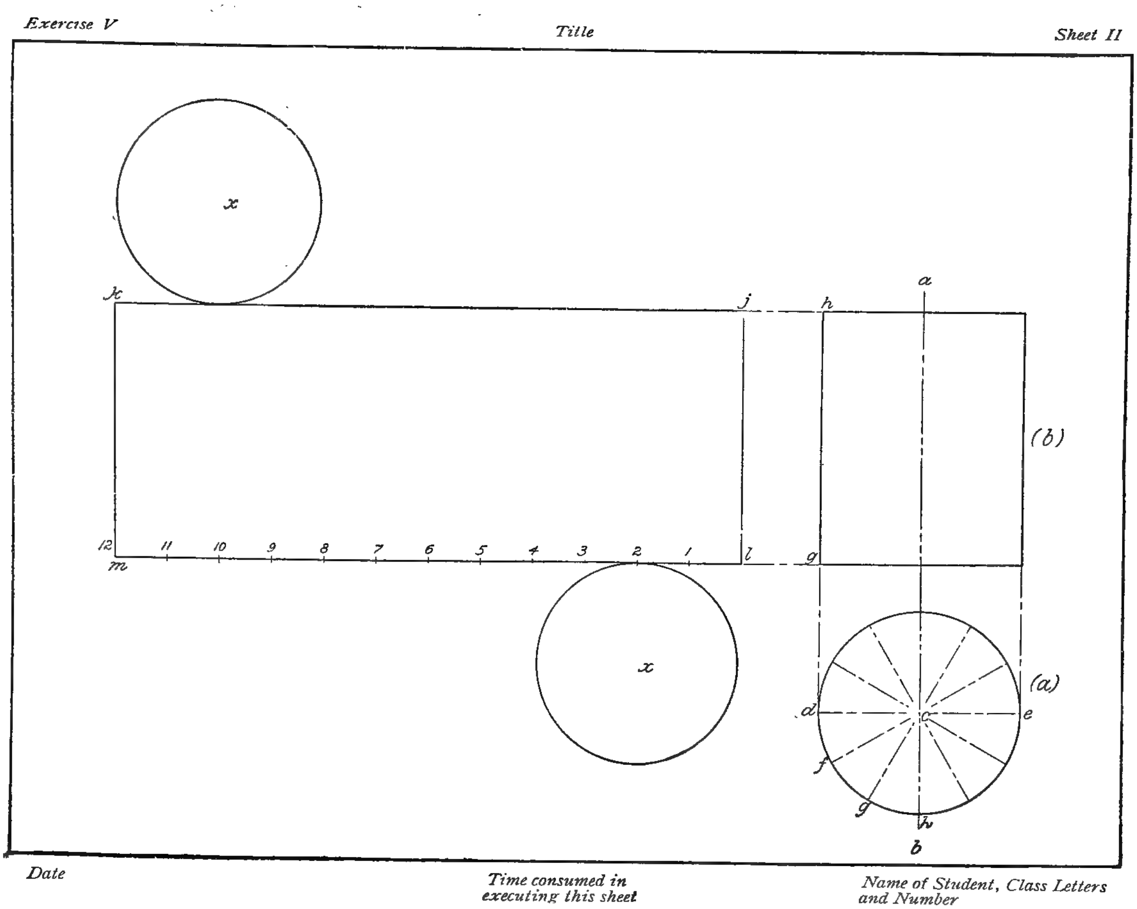
mark off *e f* on the line *l m* six times, locating the angles of the sides of the prism at *1*, *2*, *3*, etc. until six sides have been laid off. Through the points so located draw vertical lines until the six panels are completed. With the corners marked *5* and *6* as centers, with the compasses set at a distance equal to *e f* of (*a*), strike arcs intersecting at *o*; this point will establish the center of a hexagon whose sides are equal to the distance *5–6*. Draw this hexagon as the base of the prism and draw a similar one as the top. Thus, *j l m k* may represent the development of the surface of the sides of the hexagon, and the two hexagons at the top and bottom will represent the surface at the top and bottom of the hexagonal prism. Ink in, carefully, the plan and elevation of the prism and the development of its sides, top and base. The construction lines may be left in pencil, and all lettering omitted except the title, exercise number, sheet number, name, date, etc.

21. PROBLEM 30. Exercise V, Sheet II.—Problem 30 is the development of a cylinder whose plan is shown at (*a*) and elevation at (*b*). To draw this problem locate a center line *a b* for the plan and elevation 2″ to the left of the right border line, and 1½″ above the lower border line locate the center *c* of a circle 2″ in diameter that is to represent the plan of the base. Project from the sides of this circle *d e* its width into the elevation, making the height *g h* 2½″. Divide the plan into twelve equal parts, as shown at *d f g h*, etc., by means of the 30° and 60° triangles. Draw two indefinite lines *j k* and *l m*, making the distance *j l* equal to the height of the prism *h g*. With the compasses, measure off one of the twelve subdivisions of the plan, as *d f*, and lay it off along the line *l m* twelve times as indicated at *1*, *2*, *3*, *4*, etc. This will represent, approximately, the circumference of the cylinder rolled out. Draw the lines *j l* and *k m*. From divisions *2* and *10*, draw vertical lines below and above the developed surface; and with a radius of 1″ and centers on these lines at *x*, describe two circles tangent to the developed surface that will represent the development of the top and base of the cylinder.


Exercise V
Title
Sheet II
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k
j
h
a
(b)
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11
10
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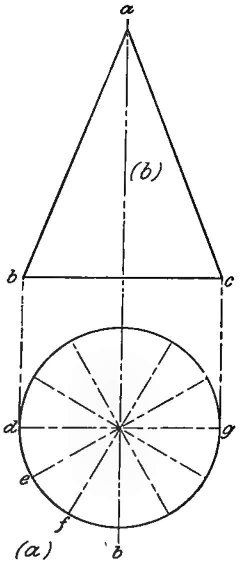
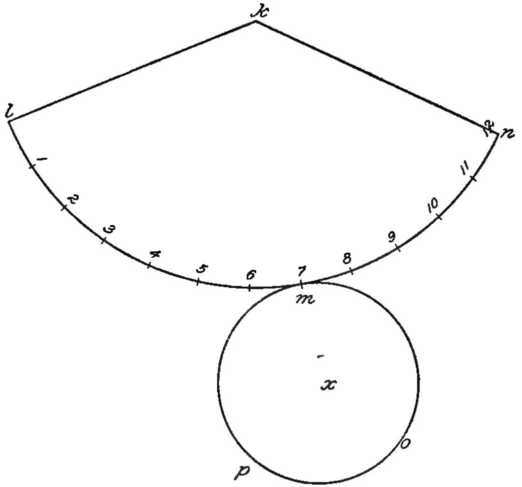
Exercise V *Title* *Sheet III*





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Ink in the plan, elevation, and development of this cylinder, but omit all lettering except the title, name, date, etc.

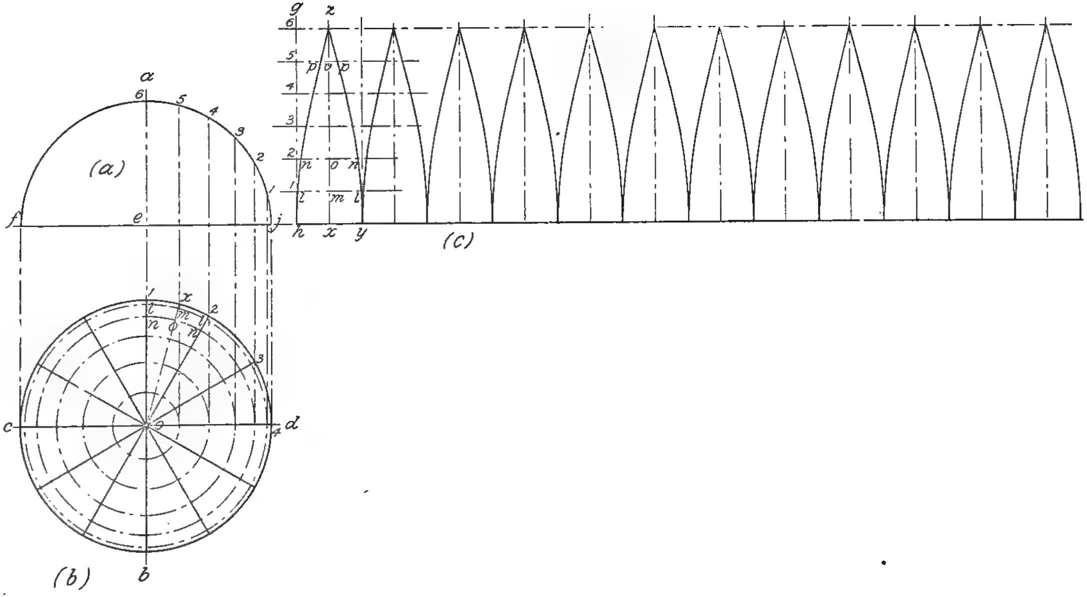
22. PROBLEM 31. Exercise V, Sheet III.—In Problem 31, a cone is represented, but the principle is exactly the same whether the figure is a cone or a pyramid. The center line *a b* of the plan and elevation is drawn 2″ to the right of the left border line, and the center of the circle representing the base is $1\frac{1}{2}''$ above the lower border line. The elevation can then be drawn with its base about 3″ above the lower border line, making the altitude of the cone $2\frac{1}{2}''$. Divide the circumference of the cone into twelve equal parts in precisely the same manner as was done with the base of the cylinder on Exercise V, Sheet II, as at *d e f*, etc. Now, in any convenient place, draw a line *k l* equal to the length of *a c* one of the elements of the cone. With *k* as a center and a radius *a c*, draw, indefinitely, the arc *l m n*; and on this arc lay off twelve sudivisions, as shown at *1*, *2*, *3*, etc., each one equal to *d e* of the plan *a*. From the twelfth subdivision draw *n k*. At any point within the subdivisions draw a tangent circle *m o p* whose center *x* is 1″ beyond the arc *l m n* and whose diameter is 2″; *l m n k* will then represent the development of the side of the cone and *m p o* the development of the base. Ink in the plan, elevation, and developed surfaces, leaving the construction lines in pencil, but omit all lettering except the title, date, name, etc.

23. PROBLEM 32. Exercise V, Sheet IV.—Problem 32 is the development of a hemisphere. This is somewhat more complicated than either of the two previous problems but in no way more difficult if the principle is understood. After drawing the border line 8″×11″, locate the center line *a b* $1\frac{1}{2}''$ to the right of the left border line, and with the center *o* 2″ above the lower border line, and with a radius of $1\frac{1}{4}''$ draw the circle *c b d* representing the plan of the hemisphere. On the line *a b* at *e*, 4″ above the lower border line, locate the center of the semicircle *f a j* whose radius is $1\frac{1}{4}''$. As the surface of this solid is curved in two directions, it is practically impossible to develop it in one unbroken surface;

Exercise V

Title

Sheet IV



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therefore, it must be considered as a figure with a number of flat sides and developed accordingly, as follows:

Divide one-half the semicircular elevation *a j* into six equal parts, as shown at *1*, *2*, *3*, *4*, *5*, and *6* in the elevation (*a*), and draw the line *g h* 3″ to the right of the border line. On *g h* lay off the distances *h 1*, *h 2*, *h 3*, etc. so that the individual spaces *1–2*, *2–3*, *3–4* will be equal to *1–2*, *2–3*, *3–4* in the elevation (*a*). Through these subdivisions, on the line *h g*, draw horizontal lines. Now divide the circumference of the plan (*b*) into twelve equal parts as shown at *1*, *2*, *3*, etc. Subdivide any one of these parts, as *1–2*, at *x*. With the compasses, lay off the distance *1 x* from the base of the line *g h* in (*c*) so that *h x* and *x y* will be equal to *1 x* and *x 2* in the plan (*b*). Draw the vertical line *x z*. Project lines from *1*, *2*, *3*, *4*, etc. in elevation (*a*) to intersect with *c d* the diameter of the plan (*b*), and at these points of intersection draw concentric circles as shown, each circle representing the horizontal diameter of the section of a sphere at the points indicated at *1*, *2*, *3*, etc. of the elevation. In the plan, the width *1 x*, *x 2* corresponds to the width *h x* and *x y* in the development (*c*), but we must now lay off *l m*, which is taken from the first concentric circle in (*b*), and make it equal to *l m* in the development (*c*) and *n o* on the second concentric circle equal to *n o* in the development (*c*), and so on with each concentric circle up to the last where the fifth concentric circle is laid off in (*c*) as shown at *p v*. Through the points thus located, a curve *h l n p z* is drawn on one side and *y l n p z* on the other. This triangle *h y z*, with the curved sides *h z* and *z y*, represents one of the twelve forms that will exactly bend over the surface of the hemisphere; and by repeating this form twelve times, as shown, we have, as in (*c*), the development of this hemispherical surface. Ink in the plan, elevation, and development, showing the subdivisions in the circumference of the plan and semi-circumference of the elevation. Leave all construction lines in pencil, or dot them in ink, and omit all lettering except the title, name, date, etc.

Particular attention must be given to these problems in order that they may be fully understood, as they constantly reappear in connection with problems in design, and their practical application must frequently be made use of.

24. The method of developing the surfaces of a sphere, cone, or cylinder by dividing the sides into any given number of equal parts is not absolutely accurate, inasmuch as each part, when taken off the circle, is not the true length of the arc but its chord, and the development of the surface therefore is somewhat shorter or smaller than the actual length. For practical purposes, however, this is usually sufficient, as the greater number of subdivisions will bring greater accuracy of length; but where exactitude is required, as in certain sheet-metal work, the true length of the curve should be calculated.

The circumference of a circle is slightly more than $3\frac{1}{7}$ times its diameter, therefore by multiplying the diameter by $3\frac{1}{7}$ we have at once the length of the developed circumference of the circle. Taking the cylinder drawn on Exercise V, Sheet II, we find that a circle 2″ in diameter should have a circumference of $6\frac{2}{7}''$. A comparison of this true length with the length on Sheet II will give an idea of the slightness of the inaccuracy of this method. When the problems on these sheets are all completed, each sheet should be lettered with the title DEVELOPMENTS and other lettering in the proper places and all the sheets sent to the Schools for correction.

PERSPECTIVE PROJECTION

25. The essential difference between the representation of an object in a projection drawing and its appearance in a perspective drawing is that in the former all the parallel lines bounding surfaces are drawn parallel in the projection to the actual size or scale of the object for which they exist. In perspective, however, the parallel lines bounding the edges of surfaces converge toward a point unless these surfaces are directly in front of and parallel with the eye.

In Fig. 1 is shown the projection drawing of a cube, wherein it can be seen from the plan (*a*) that the corner *e* of the cube is toward the observer and its sides recede at angles of about 45° toward the right and left, and in the elevation (*b*) two sides of the cube are seen—the corner *e* separating them.

In Fig. 2, the same cube is shown in perspective, and the sides that were parallel in Fig. 1 are seen to converge—*a b*, *c d*, and *e f* converging toward the right, *d b*, *c a*, and *eg* converging toward the left. It is therefore evident that if we know the position of the several points toward which these lines converge, we can draw an object in perspective and represent its details very much as it would appear to the eye.

The points toward which parallel lines converge are called **vanishing points**, and their positions are dependent on the position of the object to which they pertain. The more distant the object is placed from the eye, the farther separated are the two principal vanishing points. The vanishing points of all horizontal lines are on a level with the eye; and the horizontal straight line passing through them all is called the **horizon.** Whenever in a drawing an object is said to be above or below the horizon, above or below the level of the eye is meant; in one position it is looked up to, and in the other position it is looked down on.

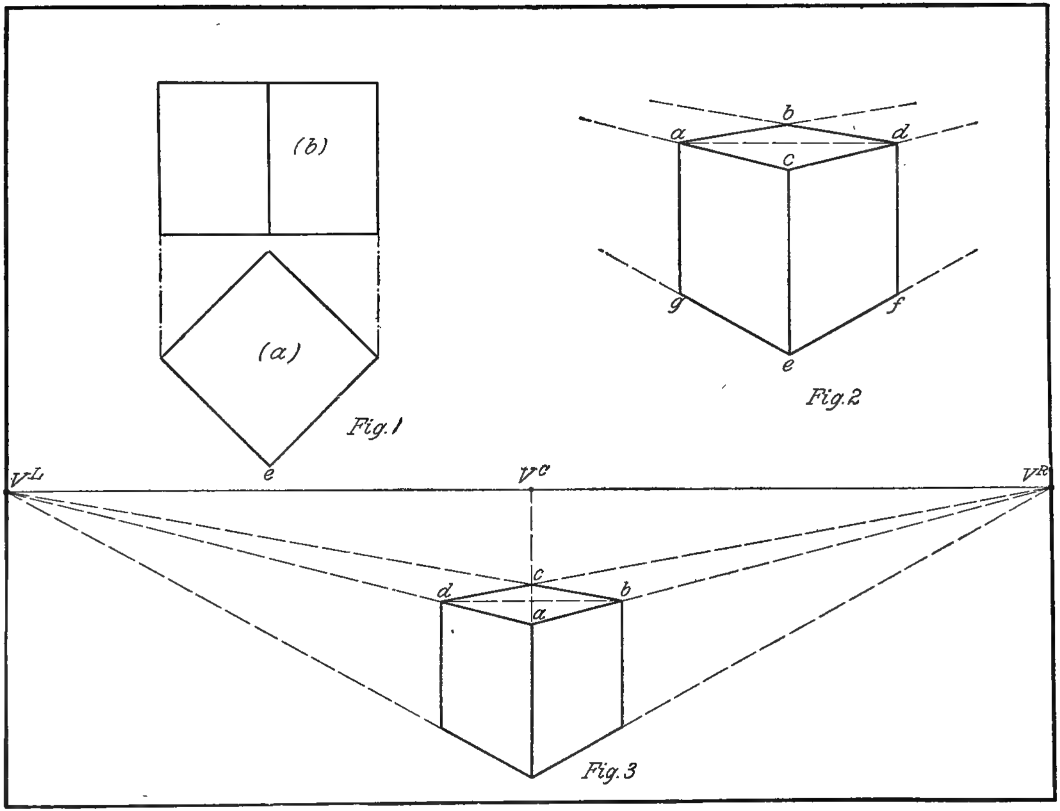

Fig. 1

Fig. 2

Fig. 3

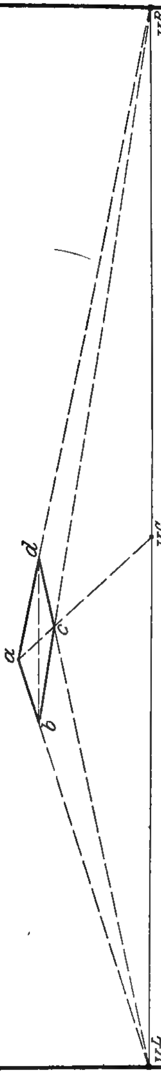

Fig. 4

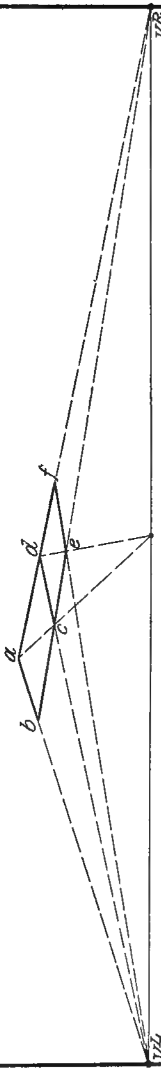

Fig. 5

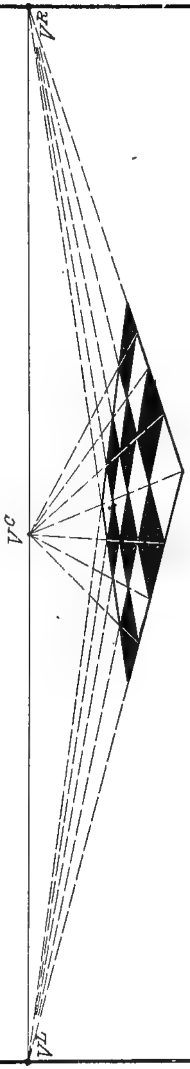

Fig. 6

For practical purposes, it may safely be assumed that the two principal vanishing points are twice as far apart as the eye is from the object. If, then, it is desired to draw the perspective of a 4-inch cube as it would appear 24 inches from the eye, proceed to lay out the vanishing points 48 inches apart, as in Fig. 3, V^R being the vanishing point toward the right and V^L being the vanishing point toward the left. The position of the cube relative to the horizon affects its appearance only so far as we see more or less of its top or base. In Fig. 3, it is considerably below the horizon and therefore a full view of the top is obtained. Now, this top *a b c d* is in reality the perspective of a square, and if a diagonal is drawn through the square from *a* to *c* and prolonged until it intersects the horizon, we have at V^C the vanishing point of the diagonal of the square; or, in other words, the vanishing point of lines at an angle of 45° with the principal lines; or, still simpler, the vanishing point of all horizontal lines perpendicular to the horizon. The other diagonal of the square *b d* is parallel to the horizon and has no vanishing point, as no matter how far it might be prolonged it will not intersect with the horizon at any point. With these simple facts thoroughly understood, one can always draw, in perspective, a square, as the vanishing points of the sides can be placed any convenient distance apart, and the vanishing point of the diagonal will always be just half way between. Thus, assuming a convenient point *a*, Fig. 4, lines can be drawn to V^L and V^R and to V^C, and then from some point *b* another line can be drawn to V^R intersecting the diagonal at *c*. The line from V^L through *c* to *d* will complete the perspective of the square, and *b d* the other diagonal, if wanted, can be drawn parallel to the horizon. If from the point *d* another line is drawn to V^C, a diagonal *d e*, Fig. 5, of another square adjacent to the first is drawn; a line from V^L through *e* to *f* completes the second square. Thus it is easily seen that any number of adjacent squares can be completed by means of the diagonals and these three vanishing points.

In Fig. 6 is shown a checkerwork drawn entirely by this means. Pyramids, prisms, and other geometrical solids can

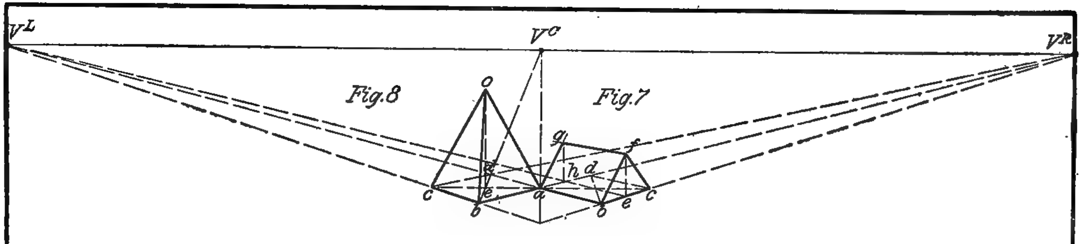

Fig.8 Fig.7

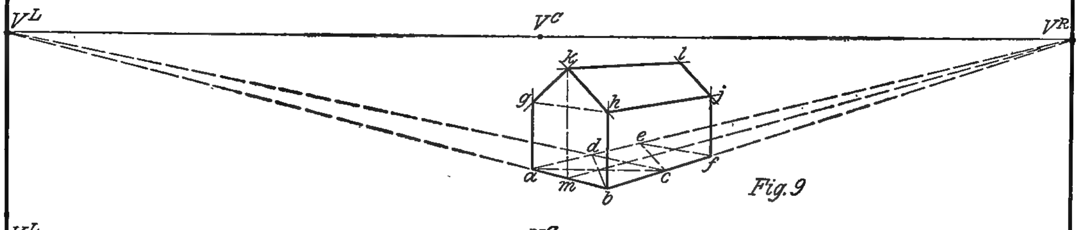

Fig.9

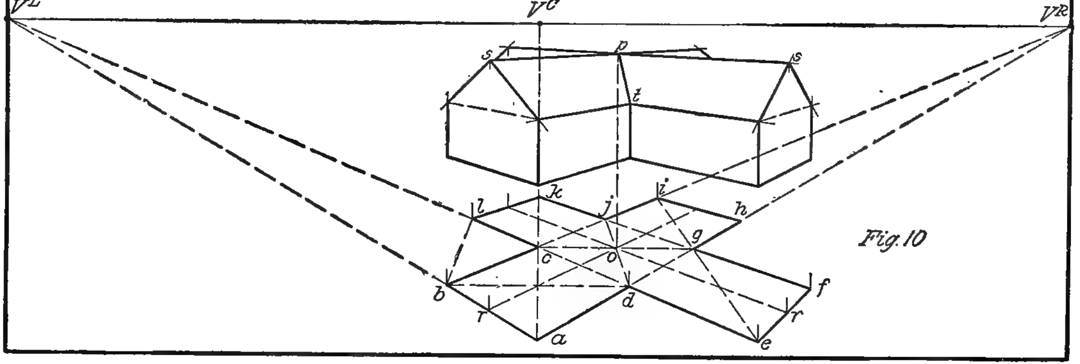

Fig.10

be represented by first drawing the perspective of their bases and then erecting over these bases the outlines of the perspective elevations.

In Fig. 7, at *a b c d*, is shown the perspective of a square and of its diagonals. A line from V^L through the intersection of these diagonals marks at *e*, the center of the side *b c*. On a perpendicular line through *e*, the apex of the triangular end of a prism may be located at *f*, and *f b* and *f c* are drawn, and from *f* toward V^L a line is drawn marking the upper edge of the prism *f g*. The point *g* is directly over *h*, where a line from *e* to V^L intersects *a d*.

In Fig. 8, at *a b c d*, is a square whose diagonals intersect at *l*. Over *e*, erect *e o*, the axis of a pyramid; lines drawn from *a*, *b*, and *c*, meeting at *o*, complete the perspective of a right square pyramid.

In Fig. 9 is shown, at *a b c d*, a square and, at *c d e f*, an adjacent and similar square. Perpendiculars erected over *a*, *b*, and *f* form the sides of the perspective view of a rectangular solid. From any point over *b*, as at *h*, lines are drawn to V^L and V^R, establishing the upper edges of the rectangular sides at *h g* and *h j*, and a line from V^R through the intersecting diagonals marks the center of the side *a b* at *m*. The perpendicular *m k* contains an end of the upper edge of the prism at *k*. Draw *g k* and *h k* to form this triangular end *m*, and then draw *k l* toward V^R and *j l* approximately parallel to *h k*. Thus, in Fig. 9, is formed the perspective of a rectangular solid supporting a triangular prism—a problem precisely similar to the perspective of a small gabled house.

In Fig. 10 are shown two intersecting rectangular solids supporting two triangular prisms, a problem similar to the roof of a four-gabled house. The plan in this case is drawn far enough below the elevation to be entirely separate. It consists of a series of five similar squares, *a b c d*, *d e f g*, *g h i j*, etc.; the diagonals of the central square intersect at *o*, and by erecting a perpendicular from this point of intersection the point *p* is established where the ridges or upper edges of the prisms intersect; the points *r* in the plan are obtained by drawing the lines from V^L and V^R through *o*, thus establishing the positions of ends of the ridges in the elevation above at *s*. The line *p t* between the intersection of the ridges and the intersection of the base is a *valley* or line of intersection.

In Figs. 4 and 5, it was observed that the material difference in the appearance of an object was effected by the position above or below the horizon. Many objects, such as chairs, tables, stools, boxes, etc., are habitually seen below the eye; other objects, such as doors, windows, bookcases, mantels, etc., are seen on a level with the eye or partly above and partly below, but roofs, towers, spires, etc. are habitually seen entirely above the eye. However, there are occasions when one stands on a high building and looks over a city, or on the side of a hill and looks over the valley, and the entire view is below the eye. Such a view as this, when rendered in perspective, is usually called a *bird's-eye view;* and in architecture the bird's-eye view is of vast importance, as it enables us to lay out the roof constructions and surrounding details of a building entirely independent of surrounding influences.

EXERCISE VI

26. This exercise will consist of seven problems laid out on five sheets. Execute the following problems in perspective according to the instructions given. Each sheet will be 9″ × 12″ with border line 8″ × 11″. Draw a horizontal line 4¾″ above the lower border line to represent the horizon line, in each of the cases 11″ long. The extreme ends of the horizon should be marked V^L and V^R and the center V^C.

PROBLEM 33. Exercise VI, Sheet I.—Take any point about 2½″ below the horizon and 1″ to the right of a perpendicular let fall from V^C as at *a*, and draw lines therefrom to V^L, V^R, and V^C. The lines from *a* to V^L and V^R will then form the sides of a rectangle, in perspective, and the line from *a* to V^C will form the diagonal of a square in perspective. At any convenient point, such as *b*, draw a line toward V^R intersecting the diagonal at *c*; and through *c* from V^L draw *c d*. Then, with the **T** square, draw *c e* parallel to the horizon and draw *e f* toward V^L; *c e* is the diagonal of

Exercise VI

Title

Sheet I

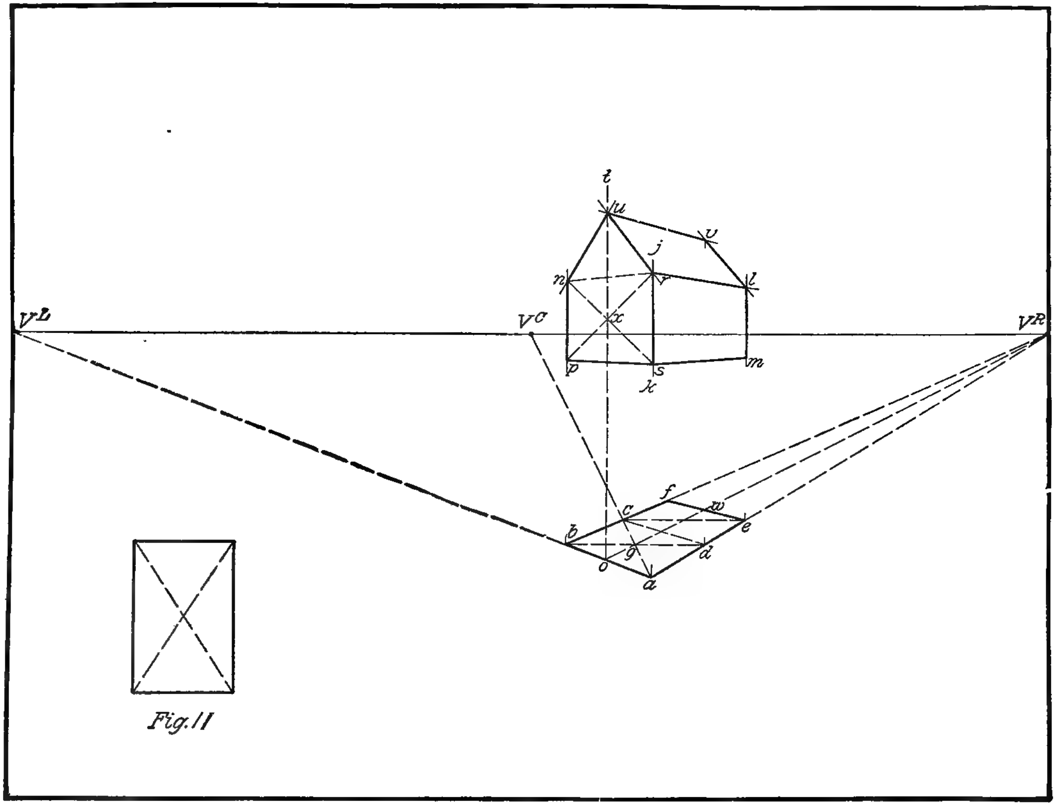

Fig. 11

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an adjacent square. Draw the other diagonal of the first square *b d* intersecting *a c* at *g*, and draw the center line from *g* toward V^R and out to *o*. Directly above *a* and across the horizon draw the indefinite line *j k*, and similarly above *e* and *b* draw *l m* and *n p*. Now, on *j k*, lay off the point *r* about $\frac{5}{8}$ above the horizon and *s* about $\frac{1}{4}''$ below the horizon, and from these points draw lines toward V^L until they intersect with the line *n p*, and also from *r* and *s* toward V^R draw lines until they intersect with *l m*. Thus, we have a perspective view of a solid figure whose end *n r s p* is a square and whose side *r l m s* is a rectangle consisting of two squares. The center of the end square is shown on the plan at *o*, and a line from *o* to *t* will establish the center line in the perspective elevation. From any point as *u* on *o t* above *n r*, draw lines to *n* and *r*, forming a gable, and the ridge may be drawn toward V^R, while the rear gable *l v* may be drawn by locating *v* directly over *w* and on the line from *u* to V^R. Or, to be exact, the point *v* may be established on the ridge of the roof *t v* over the point *w* in the plan where the ridge passes through the wall.

It is a demonstrated fact in geometrical drawing that the diagonals of any rectangle intersect each other at the center of that rectangle, Fig. 11, and therefore whenever in perspective drawing a rectangle in plan or elevation is met its center may be found by drawing diagonals. Therefore, on the end rectangle in this figure *n r s p*, diagonals may be drawn intersecting at *x*, and through *x* a perpendicular can be drawn to locate the point *u* as the ridge of the roof instead of projecting this point from the plan. The use of these diagonals should always be borne in mind in laying out any figure in perspective. Furthermore, any subdivision that can be performed geometrically in simple projection can be equally well performed in perspective projection and a full knowledge of this can be used to good advantage in all branches of perspective work.

If the side of a rectangle be divided, in any manner, near one end, equal subdivisions may be laid off near the other end by means of the diagonals.

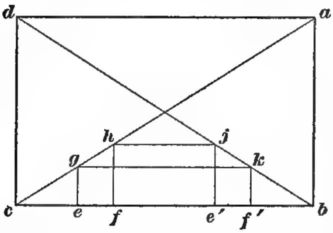
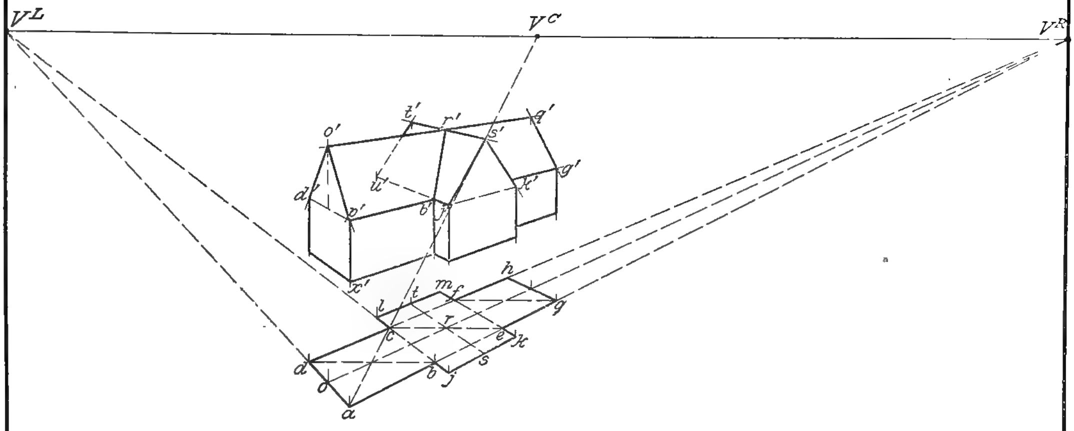


Fig. 12

In Fig. 12 we have, in the rectangle *a b c d*, the diagonals *a c* and *d b*, while at *e f* are two points on the side *c b* nearer the end *c*. If the lines *eg* and *f h* are drawn parallel to the side *c d* until they intersect with the diagonal *a c* and from these points of intersection the lines *h j* and *g k* are drawn until they intersect with the diagonal *d b*, lines drawn from the points *j* and *k* parallel to the side *a b* will intersect the line *b c* at e' and f', so that the distances $b f'$ and $e' f'$ will be equal to the distances *c e* and *e f*.

27. Problem 34. Exercise VI, Sheet II.—To work this problem, lay out the horizon line and letter it as before; assume a point $3\frac{3}{4}''$ below the horizon and $2''$ to the left of a perpendicular dropped from V^C, and from it draw lines, as shown to V^L and V^R. Draw the diagonal *a c* from *a* toward V^C and construct a square similar to that in the previous figure by drawing a line from some point *b* to V^L until it intersects *a c* at *c*, and complete the square by means of a line from V^R through *c* to *d*. Draw *c e* and from V^L draw *f e*; then draw *fg* and complete the third square *e f g h* by a line from *g* toward V^L intersecting *d h* at *h*. Continue the line *c b* somewhat beyond *b*, and draw *j k*; and similarly beyond *c* draw *l m*. The distances from *c* to *l* and from *b* to *j* can be about $\frac{1}{8}''$ or $\frac{1}{4}''$. Draw the diagonal *d b*, and where it intersects with the diagonal *a c* draw the center line that marks the end of the gable in plan at *o*; also, draw from V^L a line through the point of intersection of *c e* with the ridge, and through this point draw *s t*, the ridge of the wings of the house. Now construct entirely below the horizon a bird's-eye view showing this simple figure consisting of rectangular solids covered with intersecting prisms. For convenience, assume first the point p' about $1\frac{3}{4}''$ below the horizon and directly over *a*. Draw similar lines over *d*, *b*, *j*, *k*, and *g*. Now, from p' draw a line toward V^L until it intersects $d d'$, *Exercise VI* *Title* *Sheet II*



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and also draw a line from p' toward V^R until it intersects $b\,b'$, and continue this line between the lines $k\,k'$ and $g\,g'$. From V^L draw $b'\,j'$. From V^R, through j', draw a line until it intersects $k\,k'$. Draw $o\,o'$. From o', draw a line to V^R until it intersects with $q\,q'$; then draw $q'\,g'$. Draw over r the construction line $r\,r'$, and through r' from V^L draw a line until it intersects $s\,s'$ and $t\,t'$. Draw $s'\,j'$ and $s'\,k'$. Draw, also, $t'\,u'$ showing the portion that extends beyond $o'\,q'$ as a dotted line. We have then the construction, in perspective, of two intersecting triangular prisms similar in form to the roof of a four-gabled house; and if from x' lines are drawn toward V^L and V^R to complete the ground line of the house as shown, the whole figure presents a bird's-eye view of the required solids.

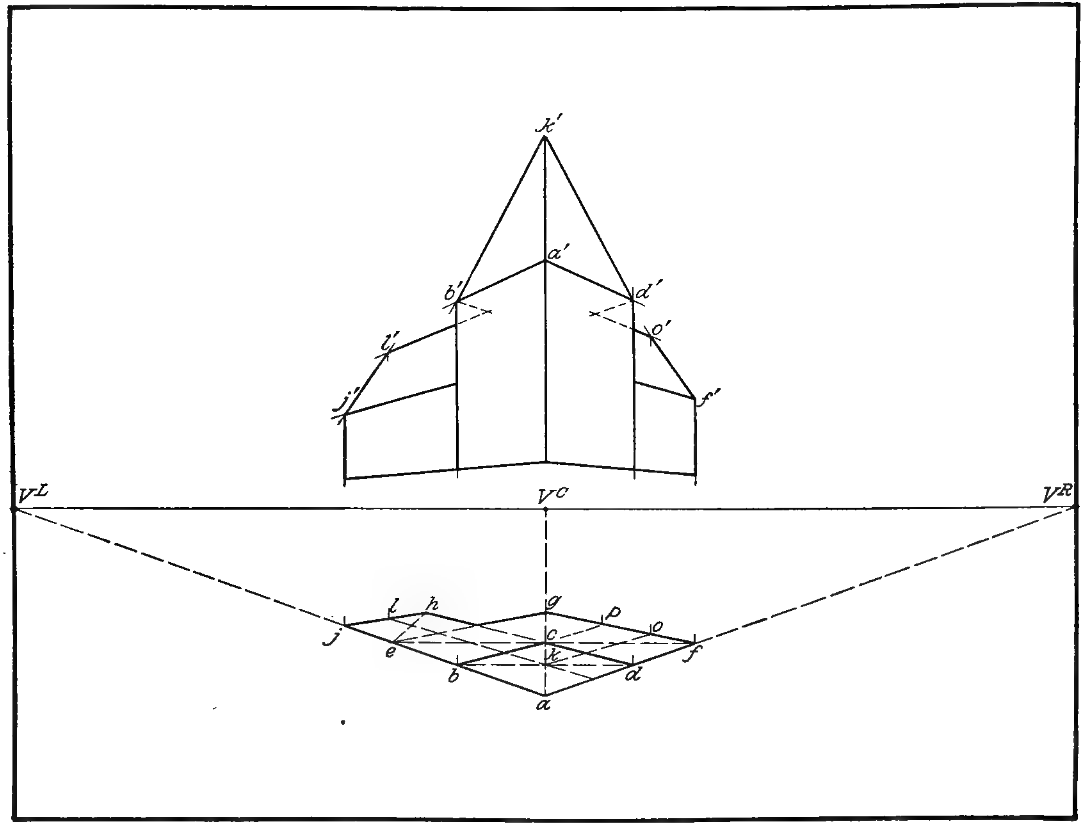
28. PROBLEM 35. Exercise VI, Sheet II.—(Position of building changed.) For Problem 35 repeat the figure in Problem 34 in the same position relative to the two vanishing points, but with the horizon passing through it $\frac{1}{4}''$ above x'; in other words, draw $x'\,p'$ so that it is about $\frac{5}{8}''$ in length and extends $\frac{3}{8}''$ above and $\frac{1}{4}''$ below the horizon. This will change the appearance of the roof materially, and the part $t'\,u'$ will disappear entirely behind $o'\,q'$ and the part $r'\,q'$ will partially disappear behind $r'\,s'$. The same plan can be used, and the instructions for drawing the perspective elevations can be followed letter for letter, care being exercised to see that the diagonals at intersections are constructed properly. Problem 3 can be executed on the same sheet as Problem 2.

29. PROBLEM 36. Exercise VI, Sheet III.—In Problem 36, the construction of the plan is entirely below the horizon and the elevation is entirely above. Draw the horizon $V^L\,V^R$ 3″ above the lower border line. From V^C, draw a vertical line and 2″ below the horizon locate the point a. Draw lines from a to V^L and V^R. Locate b about 1″ from a and complete the perspective square by means of a line $b\,p$, drawn from b toward V^R, which intersects the diagonal from a to V^C at c, and a line from c to d from V^L through c. It will be observed here that the diagonal of the square is

Exercise VI

Title

Sheet III



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perpendicular to the horizon in this particular instance. This is caused by the point *a* being exactly in front of the eye. *e f* is now drawn through *c*, and from *e* and *f* lines are drawn to V^L and V^R intersecting the diagonal at *g*. Now we have four squares in plan grouped so as to make one large square *a f g e*. The diagonal from *e* toward V^C intersecting *d h* at *h* gives us a fifth square when we draw the line *h j*. $2\frac{1}{2}''$ above the horizon locate the point *a'*. Draw *a' b'* and *a' d'*, locating the points *a' b'* and *d'* directly over *a*, *b*, and *d* of the plan. $1\frac{1}{4}''$ above *a'* locate the point *k'* directly over *k* in the plan, and draw *k' b'* and *k' d'*. Then we have a square pyramid on the top of a square rectangular prism, or a similar problem to a square tower with a pyramid roof. Draw *j j'* and locate the point *j'* 1'' above the horizon. From V^L draw a line through *j'* intersecting *b b'*. Locate *l'* $1\frac{1}{2}''$ above the horizon, and directly over *l* in the plan; draw from *l'* the ridge of the roof until it disappears behind *b b'*. Locate *f'* $1\frac{1}{8}''$ above the horizon, and *o'* $1\frac{3}{4}''$ above. Then complete the right wing as indicated in the illustration.

These exercises show the effect of drawing the perspective view above or below the horizon. The rendering of it in Problem 36 indicates a house as it would appear on a hill entirely above the eye, while in Problem 34 the drawing shows a building as it would appear in a bird's-eye view. The method of drawing is precisely the same in each case, and the position of the horizon alone is responsible for the two effects.

30. So far the reproduction of rectangular forms in perspective only have been considered. In Fig. 13 is shown, at *a b c d*, a square surface in perspective, the sides *a b* and *d c* being parallel to the horizon; therefore the drawing is said to be in **parallel perspective**. The sides *a c* and *b d* vanish in the center at V^C, and the diagonals *a d* and *b c* vanish at V^R and V^L, respectively. If the side of the square *a b* is divided at points *e* and *f* so that the central portion *e f* will be equal to the side of an inscribed octagon, according to *Geometrical Drawing*, Problem 18, it is possible to draw *f g* and eh to V^R and V^L, forming three sides of an octagon at $hefg$; and by locating the points k and l on the line cd by means of lines drawn from e and f to V^C, the lines lm and kn may be drawn through these points from V^L and V^R, respectively, thus presenting a complete octagon in perspective. By continuing the sides of the octagon he, fg, lm, kn until they intersect outside of the octagon, there is formed at o, p, q, r, another square whose sides or and op vanish toward V^L and V^R, respectively, and whose diagonal oq vanishes at V^C. This is the alternate of the previous square whose diagonals vanished at V^L and V^R, and whose sides vanished at V^C. It is evident that the two squares are identical in size, as they both circumscribe the same octagon and therefore $ofpg$ the side of one square is in reality the perspective equal of the side $aefb$, which is in full scale. That is, if ab is $1\frac{3}{4}''$ long, op is $1\frac{3}{4}''$ long in perspective. By this means it is possible to draw to the same scale the perspective of a square or an octagon standing vertically, as shown in Fig. 14, or a cube, or an octagonal solid as shown in Fig. 15. Over the point o, Fig. 13, is drawn the line ab, Fig. 14, equal to ab, Fig. 13, and from a and b, Fig. 14, lines are drawn toward V^R. Over p, Fig. 13, a line cd is drawn forming at $abcd$, Fig. 14, a vertical square in perspective.

If on ab the points e and f are laid off so as to make the line $aefb$, Fig. 14, equal in every respect to $aefb$, Fig. 13, and from f and e, Fig. 14, lines are drawn toward V^R locating the points k and l, the sides of the inscribed octagon can be located by drawing vertical lines from f and g, Fig. 13, and connecting the points so located on points a and c and b and d with diagonals as shown. This is a matter of much importance, as the transition from the octagon to the circle consists simply in rounding the corners, as shown in Fig. 16 (a). Where the corners of the octagon abc, etc. are rounded off by tangent arcs so as to produce an ellipse, which represents the sides of the inscribed circle in perspective, and removing the circumscribed octagon, the perspective of a vertical circle is produced, as shown in Fig. 16 (b). The direction of the inclination of the ellipse at (a) and (b) varies because they are

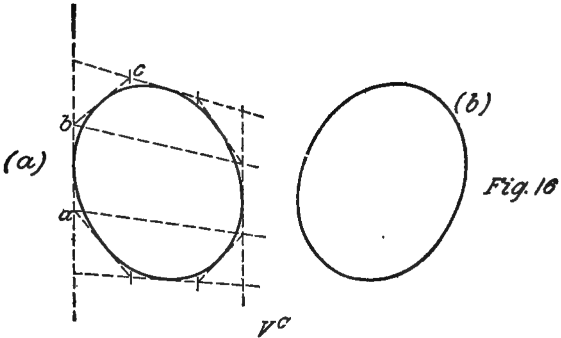


Fig. 16

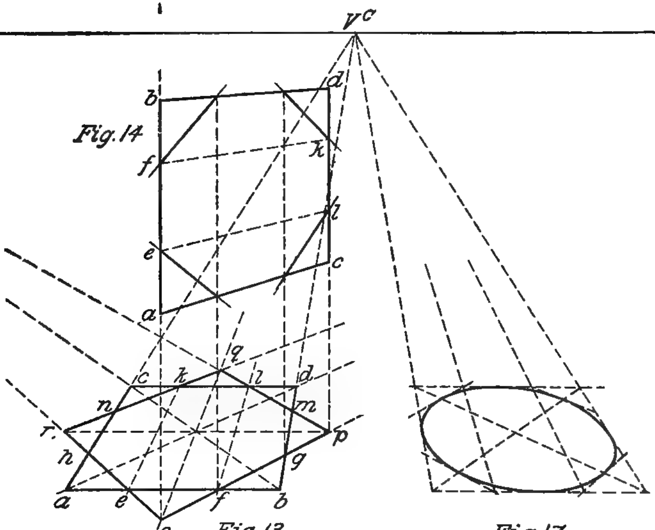


Fig. 14

Fig. 13

Fig. 17

on opposite sides of V^C. In a similar manner, the corners of a horizontal octagon similar to that shown in Fig. 13 may be rounded off so as to produce a horizontal circle in perspective, as shown in Fig 17.

In a similar manner, lines drawn from *a* and *b*, Fig. 14, toward V^L form another vertical square in perspective, as shown at *a b e f*, Fig. 18, and lines from *e* toward V^R and from *d* toward V^L intersecting at *q*, Fig. 18, form at *b d q e* another horizontal square in perspective, so that Fig. 18 now presents

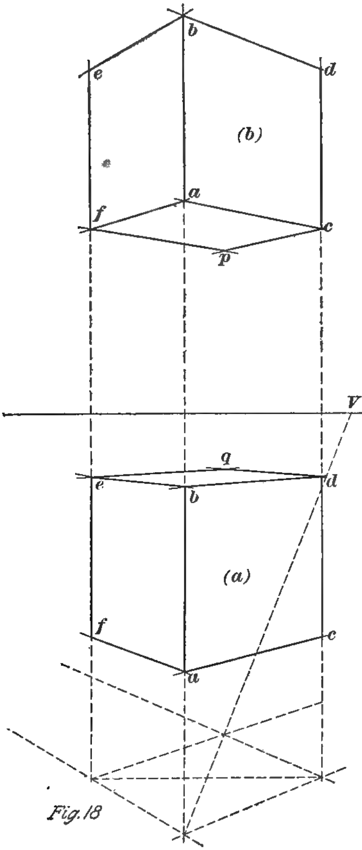


Fig. 18

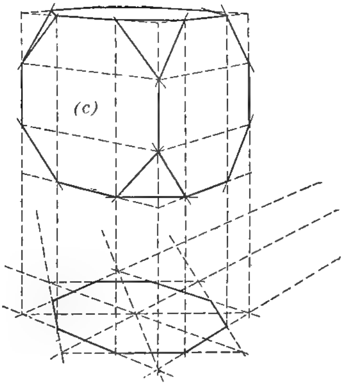
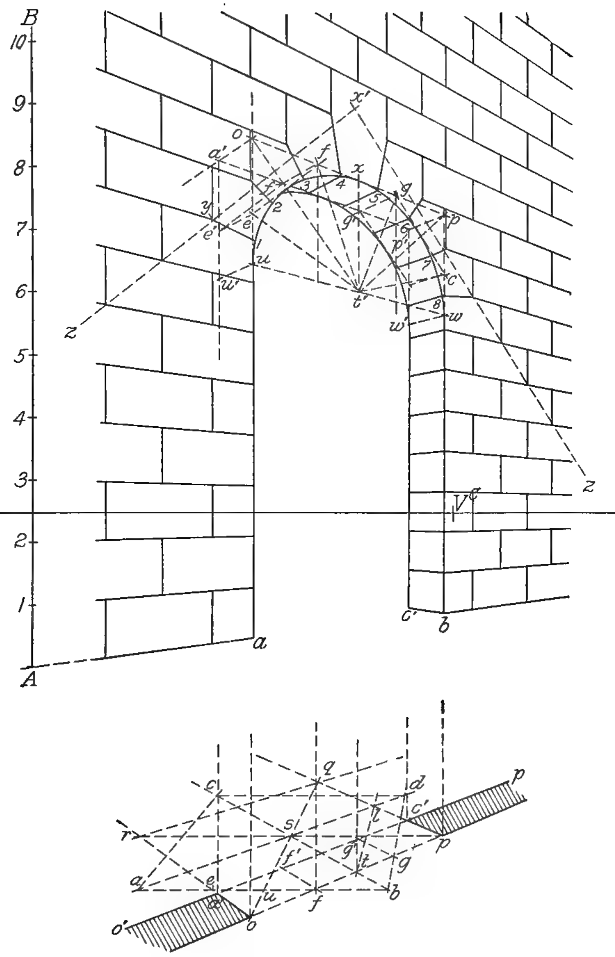


Fig. 15

the perspective drawing of a cube. The cube is converted into an octagonal solid by finding the inscribed octagon contained in its visible sides, Fig. 15.

31. PROBLEM 37. Exercise VI, Sheet IV.—The application of this system of vertical measurements is exemplified in Exercise VI, Sheet IV. Draw a horizon line 12″ long and locate V^C its center. This will necessitate the working of the problem on a larger sheet, but the drawing can be cut down when finished to the regular size. About 4″ below the horizon and $3\frac{1}{4}$″ to the left of V^C locate the point a, and draw a horizontal line ab $2\frac{1}{2}$″ long. From a draw lines toward V^C and V^R and from b to V^C and V^L; these lines will intersect at c and d and the line cd can then be drawn, making a square $abcd$ in parallel perspective. On line ab lay off ae and fb equal to $\frac{23}{32}$″, and ef equal to $1\frac{1}{16}$″ and draw from e and f lines toward V^L and V^R until they intersect the horizontal line rp drawn through the point of intersection of the diagonals ad and bc. Through r and p, lines can then be drawn toward V^L and V^R, thus completing the square $opqr$ in 45° perspective. Draw the other diagonals sp and lt of the square formed at $tslp$, and through their point of intersection, draw $o'p'$ toward V^R and cross-hatch or color the portions beyond o and p, as shown; this will represent the perspective plan of a wall with an opening through it, the thickness of the wall being $\frac{1}{4}$ the width of the opening. Above o and p draw two vertical lines, the one through o extending below the horizon about $1\frac{1}{4}$″ to a and above the horizon indefinitely; lay off on the lines over o, in the elevation, the distance ao equal to about two times the distance ab in the plan. Lay off ou and oe in the elevation equal to au and ae in the plan. The points f, g, and p in the elevation are directly over the points f, g, and p, in plan, and are on a line drawn from o toward V^R, while the point c is on a line drawn from e toward V^R. Thus, by drawing ef and gc, there is obtained $uefgcw$, a semioctagon; and by rounding the corners a vertical semicircle in perspective uxw is formed. A line drawn from V^R through a in the elevation and from b

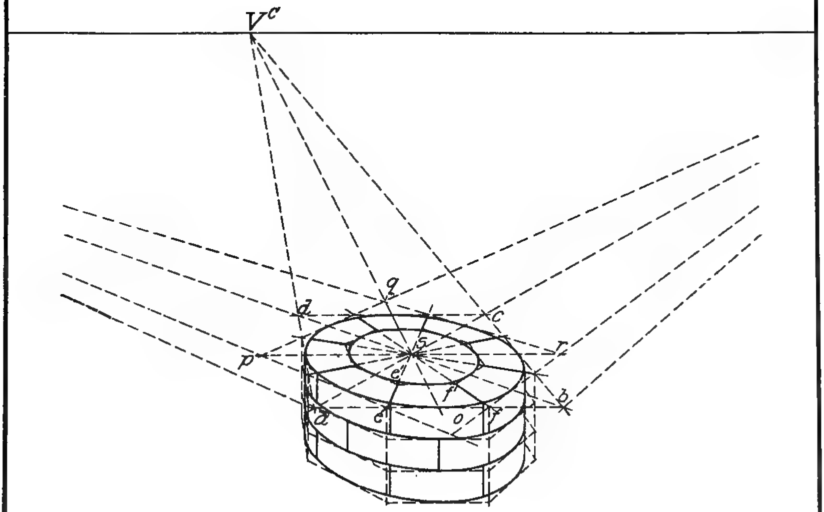
Exercise VI *Title* *Sheet IV*



Date *Time consumed in executing this sheet* *Name of Student, Class Letters and Number*

toward V^R, as shown, gives the perspective view of the outer surface of a vertical wall with an arched opening. The point c' in the elevation is directly over c' in the plan and on a line from b to V^L. The line $c'w'$ is vertical, and the point w' is on a line from w toward V^L. From o, in the elevation, draw a light line toward V^L and locate on this line the point a' directly over the point a' in plan. Draw from a' toward V^R a line until it intersects with $c'w'$ prolonged at p', thus constructing the semi-rectangle $u'a'p'w'$. Draw, in the plan, ff' and gg' toward V^L and locate f' and g' in the elevation directly over these points. Draw in the elevation ee'. Construct within the semi-rectangle $u'a'p'w'$ a semi-octagon $u'e'f'g'$, etc., and within this octagon describe what is visible of the semicircular opening of the inside of the edge of the arch. It is of no importance whether or not the vertical line above a' in the plan passes through point c, or whether or not the line $e'f'$ in the elevation falls above the line ef, so long as the construction is accurate. Locate the center of the arch t', which is directly over t in plan and is on a line from u toward V^R. Lines drawn from t' to e, f, g, and c, the angles of the circumscribed octagon, and other lines from t toward o, x, and p, which pass through the centers of the sides of the circumscribed octagon, will divide the semicircle uxw into eight equal parts. Subdividing these parts at 1, 2, 3, 4, 5, etc. gives division points of the **voussoirs**, as the wedge-shaped stones around the arch are called. Draw a line AB $1\frac{7}{8}''$ to the left of au, and lay off subdivisions on this line A–1, 1–2, 2–3, etc. $\frac{5}{8}''$ each. Draw lines from these points toward V^R until they intersect with au. Project them across the opening and from the line bw toward V^R; draw the continuation of the joint lines. Locate x' $\frac{3}{4}''$ above x. Through the point where the joint line from t' to y intersects with the line from 8 to y, draw the line $x'z$. Where yz crosses the several horizontal joints marks the position for the vertical joints between the stones; these vertical joints are over each other in every other course. On the opposite side of the arch, another line $x'z$ may be similarly drawn and the joints on that side located also.

Exercise VI *Title* *Sheet V*



Date *Time consumed in executing this sheet* *Name of Student, Class Letters and Number*

32. PROBLEM 38. Exercise VI, Sheet V.—Problem 38 is similar to Problem 37 except that the circle is rendered as a horizontal disk instead of vertical. Draw the horizon $V^L V^R$, as before, 12″ long, locating the point V^C at its center. 4″ below the horizon and ¾″ to the right of *c* locate the point *a*; draw the line *a b* 2½″ long. Construct the squares *a b c d* and *o p q r* precisely the same as in Sheet IV, thereby representing in perspective an octagon. Parallel to the side *e f* of this octagon draw *e′ f′* at any convenient distance, and then from *e′ f′* draw lines toward V^L and V^R until they intersect with the diagonals drawn from the center *S* to the angles of the octagon; thus a parallel interior octagon can be described as shown. Within these two octagons describe horizontal circles in perspective and emphasize the diagonals toward the angles of the octagons so as to represent joints in them. Below the square *a b c d* construct three or four similar squares about ¼″ apart; and within these describe similar octagons and circular arcs in perspective, thereby representing a well-curb or other circular-stone construction in perspective. Carefully ink in all the finished lines, but leave in pencil the construction lines here shown dotted.

PROBLEM 39. Exercise VI, Sheet V.—For Problem 39 make another drawing of the figure described in Problem 38, but place the line *a b* 3″ *above* the horizon, and draw *a d* and *b c* down to V^C. The figure will thus appear as if viewed from below, similar to the view one would have of any object held above the level of the eye. Therefore, after the square *a b c d* is drawn in perspective *above* the horizon, the series of semi-ellipses will be constructed above the line *a b* instead of below it, as in Problem 38. Problem 39 can be executed on the same sheet as Problem 38. When these problems are completed and the proper lettering included (the title being PERSPECTIVE PROJECTION), each sheet should be cut to the exact size of 9″ × 12″, with border line 8″ × 11″ and then mailed to the Schools *flat* for correction.

FREEHAND AND ORNAMENTAL DRAWING

INTRODUCTION

1. Necessity for the Study of Freehand Drawing. Some of the students taking up this Section have had, from a study of preliminary subjects, some training in mathematics, geometrical drawing, and projection drawing, to familiarize them with the making of certain calculations that may later be required, and to acquaint them with the use of drawing instruments and the typical geometric forms that are the basis of all drawing. Other students, however, are taking this Section as the first study of their Course. To both classes, therefore, it is proper to give some explanation as to the purpose of this Section, which may be considered as the first Section of the regular training in freehand drawing that this Course will give to them.

Not every student reading these pages has in mind the same ultimate goal. Some intend to be architectural draftsmen and architects, some have in mind the field of commercial illustrating, others are seeking to engage in some line of industrial designing, and still others aim to be trained as teachers of drawing. But to each and all of these a training in freehand drawing is of fundamental importance and absolutely necessary.

2. Fallacy of Idea of Natural Ability for Drawing. The tendency of beginners in any line of art work is to

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seek short cuts to proficiency. Just as the young student of music is eager to attempt to play composition pieces before learning the scales, so the beginner in art is prone to try to draw pictures, to design houses, book covers, wallpapers, etc., before having had his eye and his hand trained to draw even simple forms. The desire of students for such short cuts is frequently stimulated and encouraged by admiring friends, who have flattered them for their crude attempts at pictures and designs, or for their copies of the work of other artists. It is further stimulated by the incentives offered by irresponsible schools and personal art instructors, who tell these beginners that elementary study, in their case, is not required because of their unusual natural ability for drawing.

The sooner the beginner realizes that there are no short cuts and that there is no such thing as being born with an ability for drawing, the better he will be prepared to undertake a serious course of art training. One is no more born with an ability for drawing than he is born with an ability for story writing or for surgical work. It is true that one may have an inborn sense of beauty, of proportion, of humor, etc., and, through inheritance and early training, may have had his powers of observation, memory, judgment, imagination, etc., well developed. All these must be developed in the young artist who wants to be successful, but their development does not fall within the province of the art instructor. It is a common thing to hear the beginner in the study of commercial art say to his instructor: "I can copy pictures perfectly, but I cannot originate them; I want you to teach me originality." This shows an entirely wrong conception of the whole matter. These mental qualities must be acquired and developed by the student himself. No art instructor can give to the student originality, a sense of humor, keen powers of observation and memory, business enterprise, etc., and those who profess to do so are deceiving the beginner. But the duty of the art instructor is to train the student to DRAW; and beyond this he cannot honestly promise to go. (It is true he can, and should, advise the student on many features connected with the mental qualifications and business requirements, this advice being based on personal experience.) By training a student to draw is not meant training him to copy the lines and pictures made by other artists; but it means training the student's eye to see accurately, and his hand to delineate properly what he sees, so that he may later make original compositions or designs.

3. **Method of Teaching Freehand Drawing.**—The student will find that his first exercise in this Section consists simply of drawing straight lines. To the beginner, eager to become a draftsman, an illustrator, or a designer, such simple exercises may be uninteresting, or even irksome, because he may think he is being delayed unnecessarily. If he will pause to consider that, before being able to do any drawing, his eye must be trained to judge distance and proportion accurately, and his hand trained to work easily and quickly and at the same time accurately, he will then see the necessity for such practice exercises.

To start the student at once in drawing difficult still-life objects, or even human figures in repose and in action, might appear, on first thought, to be the more direct and effective way of teaching him to draw. But it is reasonable to believe that he cannot draw complicated curves and planes, or portions of the human figure in their proper foreshortened positions—even though his eye may be skilful enough to *see* these proportions—until the muscles of his fingers, hand, and arm have been so trained that they are supple and act in quick response to the commands of the eye and the brain.

Drawing is *not* illustrating or designing; it is the means by which one expresses ideas of an architectural or decorative design, or of a picture, to some one else. In view of this, it might be thought that to teach comprehensively the drawing of any specialized line of commercial or industrial art work, we should at the same time teach all about its application; but experience has shown that such a procedure complicates the work of elementary instruction. It is best for beginners to learn first how to DRAW, and then later to learn how to make technical drawings.

4. Materials Required for Freehand Drawing. *Paper:* Any good grade of white drawing paper, or "watercolor" paper, that has a "toothed" (but not rough) surface, and is not glossy, will be suitable. The T. S. Co.'s C. P. White Drawing Paper gives good results.

Pencils: An HB and a 2H of the Koh-i-noor brand are needed. Other grades may be obtained as desired.

Drawing Board, T-Square, Triangles, Scale Rule, Drawing Instruments, Eraser, Thumb Tacks, etc.—the use of which is explained on pages 6 to 20 of Instruction Paper, Geometrical Drawing, to which the student should refer—are also needed. All these materials are included in the students' outfit which—if not already on hand—should be obtained at once.

5. Blocking-in the Drawing.—Blocking-in consists of the grouping of lines and masses according to the size or scale to which the drawing is made. Before beginning to draw a figure, its general effect and characteristic shape as a whole should be carefully observed. The individual form, the curves and scrolls, and the character of the foliage should then be studied; and its symmetry and the proportion of its parts, and the direction of its movement, should be borne in mind during the entire process of sketching it in. As to the size, it is sufficient to say that some definite scale of enlargement or reduction should be followed, so that everything can be maintained in equal relative proportion. In beginning to draw an object, first lay out the extreme outline, as in Fig. 1; then locate the principal points of extent and position by measuring from the base and center lines. The extreme outline should be composed of a few straight lines so arranged as to enclose the object in an irregular geometrical figure. The curves and

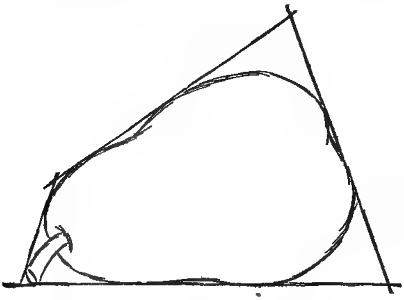


FIG. 1

other details of the object may then be rounded in at the angles of the geometrical figure, as shown. For this measuring and locating, extreme exactitude is not required; there should, in fact, be as little mechanical measuring as possible, all minor details being gauged by the eye. Use the eye as much as possible, in order that it may become trained to judge correctly of absolute and relative sizes of form and proportion. The value of this accomplishment to the draftsman or illustrator cannot be overestimated. It holds within itself the entire principle of freehand drawing. Since the object is to learn to draw, and, in a measure, to obtain a knowledge of ornament, the points just given are of far greater importance than the mere act of repeating or copying lines. The purpose of this Course is not to make copyists, but to make draftsmen, illustrators, and designers.

The same spirit applies to the drawing of the two halves of any symmetrical ornament. Except in the main points of the form, no absolute identity of the two halves is to be attempted; there is no artistic necessity for such, either in drawings or in executed work. If some little inequalities appear in the two halves of some scroll or foliage work, leave them alone and remember that good ornament is enhanced in value, rather than depreciated, by the absence of constraint or of stiff regularity. The individuality of the designer, carver, or painter shows itself in such matters, and gives character to his work.

There is another very important point to be observed in the drawing of symmetrical figures. Never draw one half complete by itself and then the other half; lay the whole ornament out as one figure and finish it up simultaneously. Above all, never trace off one half of an ornament to produce the other half. This method of working is permissible in offices and shops, on the part of experienced draftsmen, and will be permitted in future work, but must be absolutely avoided by the student in the early part of his practice in freehand drawing. Remember that, in learning to draw, nothing will train either hand or eye so well as constant practice and redrawing of the same thing.

6. Drawing the Individual Lines.—In making both straight lines and curved lines, they must be drawn in even, regular strokes, not in a succession of short scratches. The strokes must be continuous, each being a continuation of the preceding one, and as long as one unconstrained movement of the finger joints will make them, which is about $\frac{3}{4}''$. This is the best method to maintain the proper direction of the lines to be drawn, and to develop most readily the pliability of the hand and the judgment of the eye by fastening the attention and efforts of both on making a continuous line.

In drawing, the elbow may rest on the drawing board, but the ball of the hand should be as free as possible, in which position the hand will rest and travel along lightly on the first joint of the little finger.

The eye must guide the hand in drawing, but should not be riveted too closely on the pencil; a glance forwards and backwards over the work, to compare the form of the design and the direction of the lines, will enable you to keep your work close to the original, which is all that is at present desired.

In blocking-in the figures on the Exercise Sheets in this Section an HB pencil may be used; but, in drawing the individual lines of the figures, use a 2H pencil with a sharp point.

7. Object Drawing as Supplementary Practice. The method of training the student in freehand drawing that will be followed in this Section has just been explained. This is what is known as *drawing from the flat*, and is the simplest possible method of teaching form and proportion, eye measurement, dexterity of fingers, etc., to students who take up these Courses. It must be well understood, however, that this Section is only a preliminary training for the more advanced freehand work that comes later. (For instance, the student of Illustrating will later take up the work of drawing from nature, drawing from casts, drawing from the human figure, etc.).

It would be of advantage to every student, however, to do as much additional practice work as possible, aside from the regular prescribed work of this Section. This supplementary practice work should consist of making pencil drawings, in outline, of simple objects that one sees every day. In doing this work the suggestions given below should be followed.

1. *Only objects of simple form should be selected.* Objects of every-day household or office use should be used as models. Among these may be cubical or oblong boxes, such as cigar boxes, shoe boxes, containers of foodstuffs, medicines, etc., to start with. Next, cylindrical objects, such as cans, jars, goblets, etc., may be attempted, followed by those of conical, spherical, and other shapes. Start with the simpler shapes and work progressively toward the more difficult ones.

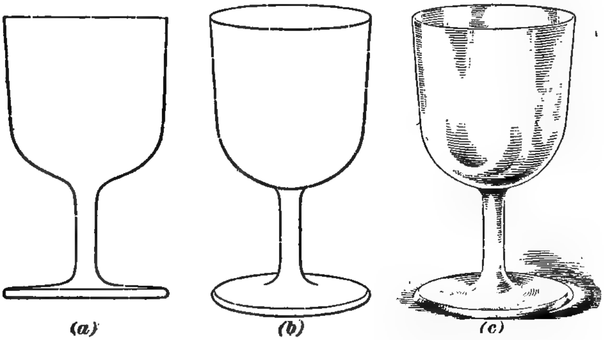


FIG. 2

2. *Method of placing the objects for sketching.* Place the object on a table of average height in such a manner that it is about on a level with the eye of one who is seated, as the goblet shown in Fig. 2 (*a*). If necessary, place a few books under the object so as to raise it to the desired height. Do not have the object below the level of the eye so that one looks down on it, as in Fig. 2 (*b*) and (*c*).

3. *Proper position when sketching the object.* The student should be seated in a chair in such relation to the table upon

which the object rests that the lower edge of the inclined drawing board rests on his knees and its back rests against the edge of the table. Sit upright when working, with the board about at arm's length; do not lean over the board.

4. *Manner of holding the pencil.* The pencil should be fairly soft, such as an HB, and should be held in quite a different manner from that described for drawing ornamental figures on a small scale. Let the pencil rest lightly on the balls of the four finger tips, these fingers being *underneath* the pencil and facing upward, the pencil being held lightly in place by gentle pressure from the ball of the thumb placed on the top of it. In this way the pencil will not be rigid in the hand (although it can be made so), but will have a certain freedom and flexibility that will greatly assist in securing a correct drawing. In this way the point of the pencil will be directed toward the top, or top left-hand corner, of the board.

5. *Method of sketching objects.* Practice making straight lines, first vertical, then horizontal, then oblique ones. After that, various curves should be attempted. If the fingers get tired or cramped, rest them. Let the arm swing free from the shoulder; do not rest the wrist or elbow on the board, merely steady the hand by resting the tips of the fingers against the paper.

Work entirely by eye measurement. The system of using the pencil held at arm's length between the eye and the object, vertically to measure vertical lines, and horizontally to measure horizontal lines, may be used. The dimensions projected on to the pencil may be marked by the thumb nail thereon, and transferred to the drawing. Draw boldly, but not hastily and carelessly. At first make the lines lightly and—if they are found to be wrong—do not erase them, but simply draw over them with heavier and more accurate lines. After each object is drawn, the drawing should be carefully compared with the contours of the object itself to see where errors have been made.

The student is NOT *to send this supplementary practice work to the Schools.* Only the regular Exercises are to be sent.

EXERCISES

NOTE.—All the drawings in this Section, including practice figures, border lines, lettering, etc., are to be drawn IN PENCIL ONLY. The use of ink is not required, for any purpose whatever, on any of the drawing sheets in the subject of Freehand and Ornamental Drawing.

8. There are in this Section six required drawing exercises, each consisting of four sheets. Each sheet, when trimmed to proper size, should be 9″ × 12″ with a border line 8″ × 11″. Each sheet of drawing paper that comes to the student from the dealers is usually 15″ × 20″, thus enabling the student to get therefrom *two* drawing sheets each 9″ × 12″. The extra margin around each 9″ × 12″ sheet need not be considered wasted, for it is useful for trying the pencil, holding the thumbtacks, etc.

All the required figures on the students' drawing sheets are to be executed entirely *freehand*, and all measurements laid off by the judgment of the eye, except in such cases where the student is told he may use instruments. Before attempting to draw any of the figures, the text directions must first be carefully read and understood.

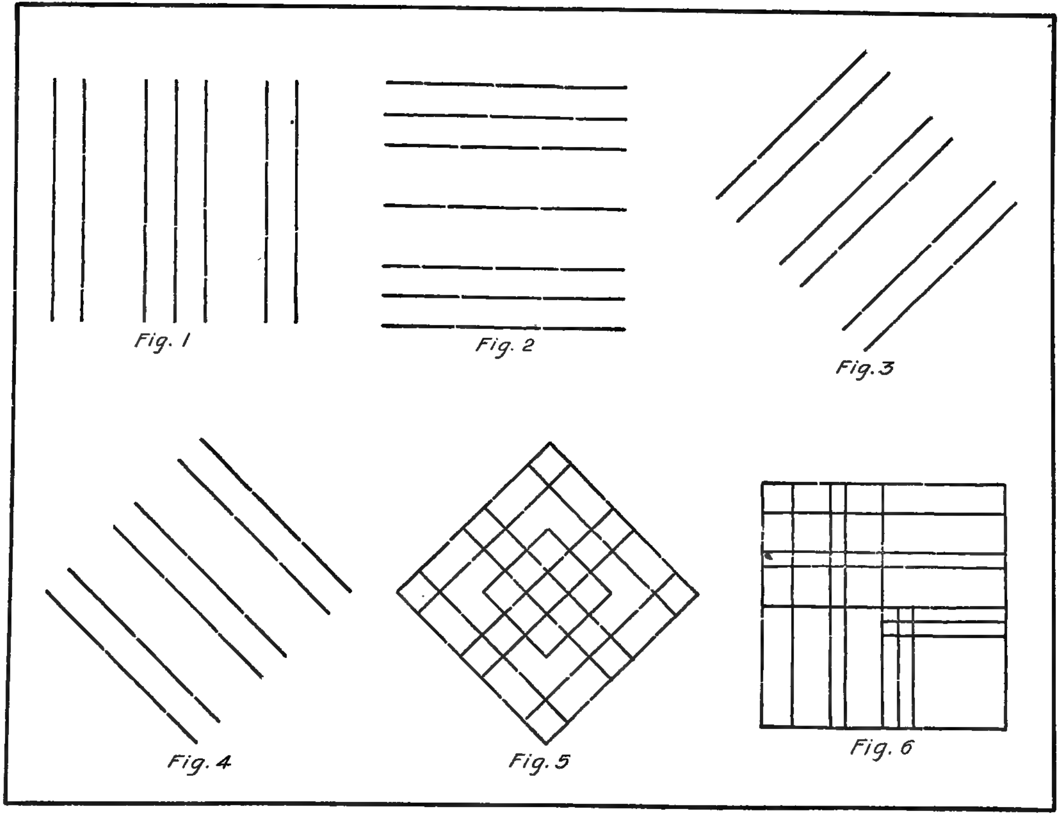
Before making the final drawings that are to be sent to the Schools as exercises for correction, the student must do a great deal of practice work on each figure.

In preparing the drawing sheets, the directions should be followed exactly as given in the following pages. When the set of sheets for Exercise I has been completed, these sheets should be placed together in the large 9½″ × 12½″ envelope, stiffened by the corrugated cardboard, and mailed to the Schools for examination. While we are examining your Exercise I you may be working on the drawings for Exercise II, but do not send these to us until your Exercise I has been returned to you.

Exercise I

Title

Sheet 1



Date

Time consumed in
executing this sheet

Name of Student, Class Letters
and Number

EXERCISE I, TITLE: LINEAR ELEMENTS

9. This exercise consists of four sheets each of which you should be able to execute perfectly without other aid than the directions herewith given. The succeeding exercises will each contain some detail or element, the instruction for which can be traced to this exercise. It is absolutely necessary, therefore, that the student should be perfect in every detail of each exercise before attempting the next one. The figures on this exercise are simple lines and combinations of lines to produce some of the elementary forms that enter largely into all classes of design. Drawing these trains the eye and hand to work together, and thereby become sufficiently practiced to execute the problems that follow. The drawing of a single line is of as much importance as the execution of an entire design, and each simple problem should be practiced constantly and patiently before the next is attempted. If each lesson is thoroughly learned, the next one will invariably prove easier.

Please note carefully that you are NOT to send us any of the small figured *text* illustrations. The exercise sheets you will prepare for us are shown in the *full-page* illustrations, enclosed in border lines, on pages 10, 21, 26, and 29.

10. In Fig. 1 of Sheet I is shown the method of drawing perpendicular straight lines. The pencil should be held lightly between the thumb and forefinger, with its upper end resting against the forefinger between the second and the third joints, while the end of the middle finger rests on top of the pencil alongside of the forefinger.

If, however, a fixed habit of holding the pencil in some other manner has already been acquired, it will probably be found simpler to continue in that way.

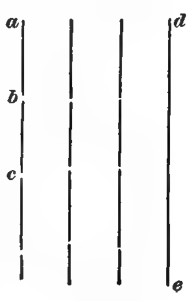


FIG. 3

The drawing board should be squarely in front and the elbow should rest near the bottom of the board, somewhat to the right of the drawing on which the student is at work. A short straight line is then drawn, as from *a* to *b* in Fig. 3, and the arm shifted a little lower down on the board, and another line, as *bc*, drawn, care being taken that there is a space of at least $\frac{1}{32}''$ between the end of the line *ab* and the beginning of the line *bc*. A third section of the line is then drawn from *c* downwards, and so on, until the line is of the desired length, which is about $2\frac{1}{2}''$. Each section of the line is about $\frac{3}{4}''$ in length, as that is about as long as the average person can draw it with one unconstrained movement of the fingers. When the pencil is drawn down as far as the fingers will conveniently act, the hand becomes cramped as shown in Fig. 4 and it should then be shifted and a new section of the line started. Having practiced this several times, gradually decrease the spaces between the sections of the line until it appears as a straight unbroken line, as shown at *de*. It is necessary to be still more careful in doing this, lest the lines overlay one another or curl out at the ends. The former error causes the finished line to appear somewhat as in Fig. 5 (*a*); while the line composed of strokes whose extremities are curled will appear ragged, as in Fig. 5 (*b*). The strokes with which these lines are made are not short quick dashes of the pencil or pen, but slow even marks, each of which is started carefully, drawn slowly, and finished abruptly, so as to show a clean, even stroke, the same weight throughout, perfectly black, and clean cut from end to end. The second stroke must never lap over the first, and it is better to let a hairbreadth space remain

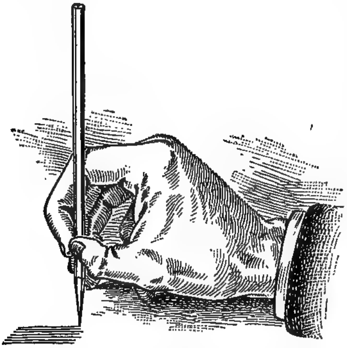


FIG. 4

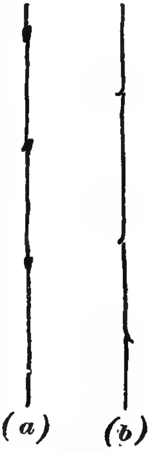


FIG. 5

between the ends of the lines than to have the least suggestion of a line like Fig. 5 (*a*). Practice this simple line exercise repeatedly, as in it lies the whole key to successful freehand drawing. When proficiency in this has been acquired, commence work on the drawing sheets to be sent to the Schools.

11. **Exercise I, Sheet I.**—First draw the limiting outline of the edge of the sheet 9″ × 12″. Then ½″ inside these lines, all around the four sides, draw the border lines, which will enclose a space 8″ × 11″, as explained for laying out the exercises in *Geometrical Drawing*. Draw a line horizontally through the 11″ length of space within the border line and midway between the top and bottom border lines. This will divide the sheet into two horizontal bands. Divide the length of one of these bands into three equal parts, and through the points of division draw light vertical lines, thus converting the surface of the drawing into six rectangles. This may all be done with the T square and triangle; but, from this point on, all work must be done freehand. Each figure must be drawn as nearly as possible in the center, between the vertical lines of its respective rectangle. Each figure of the upper row should be drawn ¾″ above the lower horizontal line of its rectangle, the bottom of the figures of the lower row being about ¾″ above the lower border line. Now draw the first figure of this exercise; this consists of seven perpendicular lines, each of which is approximately 2½″ long and spaced as shown, and about ⅜″ or ¾″ from its neighbor. Only one of them need be an absolutely solid line, the others being composed of dashes about ¾″ in length.

The drawing of horizontal lines should be practiced in a similar manner, except that the elbow should be drawn nearer the body. When the strokes forming the horizontal lines are drawn, the whole arm should be moved toward the right, in order to prevent the lines from becoming arched, as will be the case if the elbow remains fixed and the hand are moved only so far as the swing of the arm will permit. The strokes forming the horizontal lines may be somewhat longer than those composing the vertical lines, but the method of forming one straight line, by the careful union of several smaller ones, remains precisely the same for both cases.

In drawing the horizontal lines, see that perfect parallelism is maintained; the spacing between the lines, however, may be gradually increased or decreased in order to better train the eye as well as control the hand. In drawing Fig. 2 of the exercise, make the upper and lower three lines $\frac{3}{8}''$ apart, and $\frac{3}{4}''$ from the middle line, all the lines being about $2\frac{1}{2}''$ long. The lengths of these lines and their distances apart *are to be judged by eye measurement only*, which can readily be done after repeated practice on separate sheets of paper, the practice lines being frequently tested with a scale rule. No scale rule, however, is to be used when the figures on the drawing sheet are drawn.

12. Figs. 3 and 4 show two sets of parallel oblique lines, the former being drawn from right to left, and generally called *right-oblique* lines, and the latter drawn from left to right, and usually designated as *left-oblique* lines. Fig. 3 is much the easier to draw, as the slope of the lines corresponds in direction to the inclination of the letters in ordinary handwriting, and the hand is more accustomed to the angle. After practicing the right-oblique lines until assured that they can be drawn as well as the two previous sets, draw a series in the direction shown in Fig. 4 of Sheet I. To do this it will be necessary to change the position of the arm, so as to bring the elbow toward the right end of the board and the hand above, and to the right of the lines to be drawn. The lines in Figs. 3 and 4 should incline at an angle of 45°, and should be arranged in pairs, as shown, with $\frac{3}{8}''$ between the individual lines of each pair, and a distance of about $2\frac{1}{4}''$ between the extreme outside lines of each figure, the lines each being about 2″ long, all these dimensions and angles being judged by eye measurement alone.

13. Figs. 5 and 6 involve no new principle in drawing and are simply a combination of the preceding problems. Observe, however, that though these two figures contain exactly the same number of lines and nearly the same lengths of lines, they are, in appearance, entirely different. This difference of appearance is due to the composition of the figures; many changes of arrangement can be effected without altering the number or size of the lines. In line composition, the designer has but two elements to consider—the lines and the spaces. He may darken some of the spaces, thereby entering into surface composition, wherein he has at least two more elements to consider—*light* and *shade*. Fig. 6 of the text shows six problems in composition, all based on the line elements as arranged in Fig. 6 of the exercise, but treated differently as to light and shade, thus illustrating the fact that even with a few elements of composition a great variety of design may be produced. The blackening, or shading, of certain parts of a line composition, in this manner, is technically termed *spotting*, and when a plain line drawing is thus treated it is said to be *spotted*. None of the figures in this exercise are to be spotted; they are to be left entirely in outline.

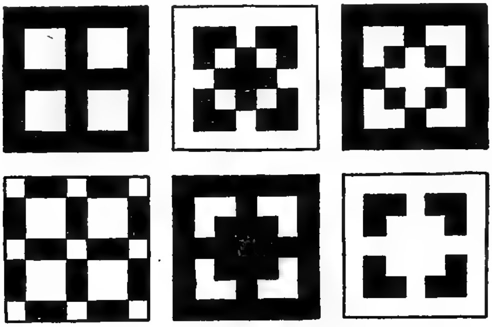


FIG. 6

To draw Fig. 5, erect a perpendicular in the center of the rectangle, and draw right and left oblique lines, each at an angle of 45°, and $2\frac{1}{2}''$ in length. These oblique lines should be drawn purely by eye measurement. It will defeat our purpose in training you to do freehand work, if you use any instruments or mechanical aids. Let these two lines be the lower sides of a square standing on its corner. Having completed the square draw $\frac{3}{8}''$ within each of its sides, a line parallel to that side, and through the center of the square draw parallel lines $\frac{3}{8}''$ apart, as shown. The small inscribed square may then be drawn, each side of which is 1″.

The square enclosing Fig. 6 is $2\frac{1}{4}''$ on each side. The lines of its composition are variously spaced from $\frac{1}{8}''$ to $\frac{3}{8}''$ from the left side and top, respectively. The same number of lines and nearly the same lengths of lines are used in both Fig. 5 and Fig. 6, but, as said before, the student can readily see the variation of effect that may be obtained by the simple arrangement of a few lines.

The exact sizes and dimensions of the several interior squares are not matters of importance to us now, and the student's drawing of this figure will be judged by the care of his execution rather than by the accuracy of eye measurement. The angles of the square must be 90°, not more nor less, and opposite sides must be perfectly parallel, while adjacent sides must be perpendicular to each other. The straightness of the lines or their exact length as to this description will not be considered. For instance, a drawing like Fig. 7 of the text will be considered as satisfactory at this stage of the work, for, though the lines are somewhat irregular, their directions are correct and they intersect at right angles; and though the inner rectangles are larger than the corner ones, they are perfect squares and are all the same size. They thus preserve harmony in the figure and avoid the appearance of irregularity and carelessness shown in Fig. 8 of the text, wherein the lines themselves are more nearly perfect, but their direction and parallelism extremely faulty. Draw Figs. 5 and 6 several times on a separate piece of paper before executing them on the drawing sheet.

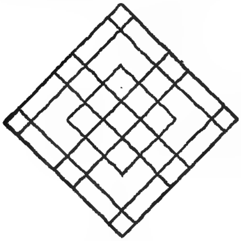


FIG. 7

These simple line exercises are of the utmost importance, as on them will depend much of the future freehand work. Practice each set repeatedly on a sheet of ordinary detail drawing paper, until able to produce, at will, perpendicular, horizontal, or oblique lines and then, but not until then, attempt to draw them on the sheet that will be sent to the Schools for correction. Each of these exercises should be drawn as carefully and as accurately as though it were a part of a complicated design. Haste will only produce slovenliness and impede the progress toward becoming a good draftsman. *Neatness*, *accuracy*, and *rapidity* are the three qualifications of a good draftsman, in the order of their importance, and the last is of no value unless accompanied by the other two, while the second is impossible without the first. After completing the figures and border line on Sheet I, carefully letter the title of the exercise, LINEAR ELEMENTS, in the center with the larger vertical lettering shown in Fig. 9, the exercise number on the left and sheet number on the right, above the upper order line, as in *Geometrical Drawing;* and the time consumed, date, name, class letter and number below the lower border line, in the smaller lettering on the 60° slant.

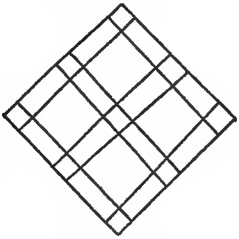


FIG. 8

LETTERING ALPHABET

14. In lettering the titles in this and subsequent Sections, the alphabet shown in Fig. 9 of the text should be used. This is based practically on the same lines as the geometrical alphabet given in *Geometrical Drawing*, except that the details are changed in order to be better suited to freehand work. While there is no objection to the pencil outlining of this alphabet with the **T** square and triangles, the finished work should be drawn freehand; and in doing this it should be borne in mind that the duplication, line for line, of the letters shown in Fig. 9 is not what is required, but an intelligent use of this form adapted as it is to single-stroke work. With a pointed soft pencil, such as an H, an HB, or a B, the vertical and horizontal lines of this

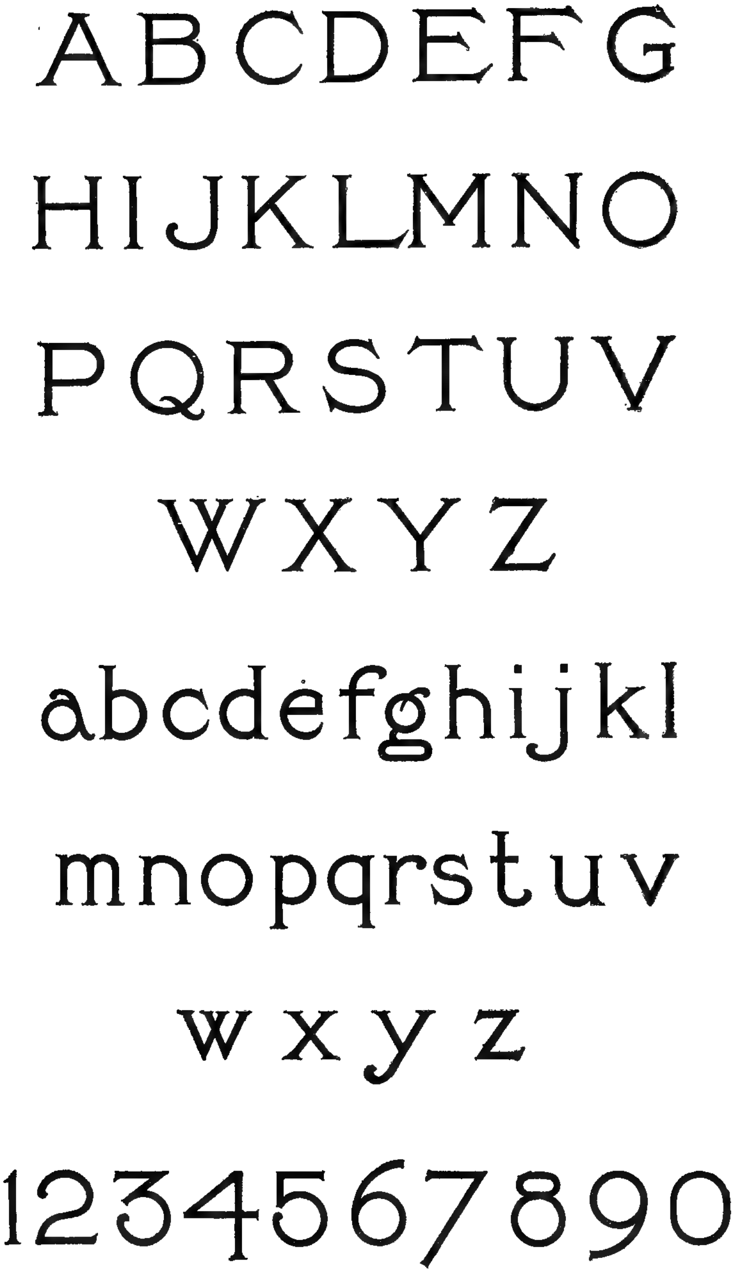

ABCDEFG
HIJKLMNO
PQRSTUV
WXYZ
abcdefghijkl
mnopqrstuv
wxyz
1234567890

Fig. 9

alphabet can be executed in two strokes placed side by side so close together that they form one in general appearance. The spurs at the ends of the strokes can be put on afterwards with a finer point, or they may be indicated simply as straight lines, and the top and bottom pieces indicated with the soft pencil in a single stroke, the angle afterwards being rounded off. If these letters are executed with a single stroke of the pencil, it will make the governing lines somewhat lighter, but there is no objection to this if the student finds it easier.

Good lettering is an essential requirement for all good draftsmen, but by good lettering is not meant perfect lettering. The uniformity of line composing the letters, and the evenness of spacing due to the intelligent placing of one letter next to another, and a proper proportioning of different sizes of letters in a title are the elements that constitute good lettering rather than the forms of the letters themselves. Some draftsmen will make the cross-line of the A particularly high; others will make it very low. There is no objection to either practice. The fact that the cross-line of the B, E, F, and H must always be above the center does not follow that it must be close to the center, and many draftsmen will exaggerate the position in these letters and make it unusually high, all of which is permissible. The vertical lines of the H, M, and N are frequently inclined so that the letter is much narrower at the top than at the bottom, and the two middle strokes of the M are frequently depressed much less than is shown in this example. Therefore, the student need not feel, in lettering his drawings, that he is to copy any particular outline. If in his endeavor to use originality he commits any serious error, it is easily corrected when his exercises are criticized, and he should devote his entire efforts to making pleasing letters rather than perfect ones.

The size of the letter is also of comparatively slight importance as long as it is large enough to suit the drawing on which it is placed. The examples here are shown $\frac{3}{8}''$ for the capital letters, and $\frac{1}{4}''$ for the body and smaller letters.

If the sizes are reduced one-half, no harm is done so long as the letters are good. Generally speaking, in practicing letters it is best to keep them fairly large in the beginning, as large letters are more easily spaced than small ones. Give particular attention to the following details:

In all letters where there is a single vertical line, be sure that this line does not incline to the right or to the left; and, in letters where there are two vertical lines, if one is inclined, the other must be inclined at the same angle. Horizontal lines at the tops and bottoms of letters must always be perfectly horizontal. But horizontal lines in the middle of letters may be altered to incline upwards toward the right. In making the letters C, O, and Q, a top-heavy appearance is avoided by making them slightly oval with the small end upwards. With slight practice, you should be able to make this alphabet directly with the pencil and not be compelled to block in the letters first.

For lettering the exercise number and sheet number above the upper border line, and the name, class letters and number, time consumed on sheet, and date, below the lower border line, the small lettering inclined at the 60° angle should be used, the letters being $\frac{3}{32}''$ high, as on the *Geometrical Drawing* exercises, or $\frac{1}{8}''$ high, just as the student prefers.

15. Exercise I, Sheet II, includes Figs. 7 to 12 and is drawn on a sheet 9″ × 12″, with a border line 8″ × 11″. The sheet is turned with the 11″ dimension as the height, and a vertical line drawn down the center, and two horizontal lines through the 8″ width, thus dividing the sheet into six equal rectangles. Each figure is then spaced in its appropriate rectangles, as before.

16. Fig. 7 is an equilateral triangle, the base of which is 3″ long. The inclination of the sides is not so easy to judge by the eye as were the 45° lines in Figs. 3, 4, and 5, but by remembering that the apex must be exactly over the center of the base, little trouble will be experienced. After the triangle is drawn, bisect the sides and draw the enclosed triangle as shown.

Exercise I *Title* *Sheet II*

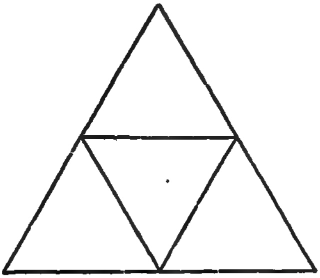


Fig. 7

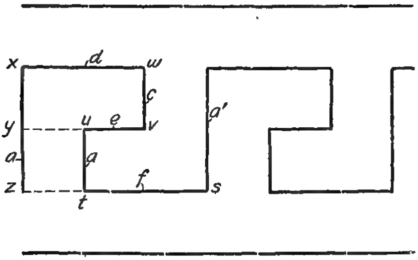


Fig. 8

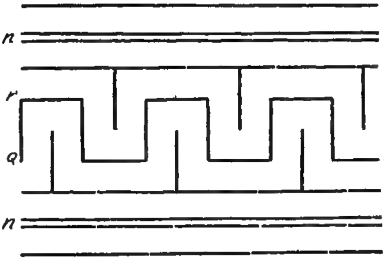


Fig. 9

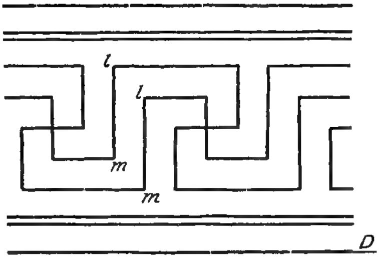


Fig. 10

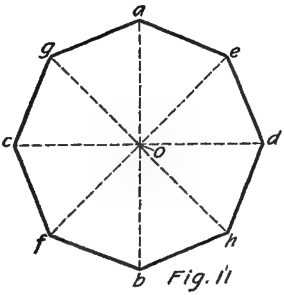


Fig. 11

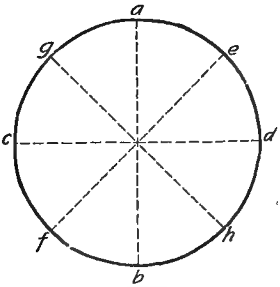


Fig. 12

Date *Time consumed in executing this sheet* *Name of Student, Class Letters and Number*

Figs. 8, 9, and 10 are examples of borders taken from Greek pottery, and are composed entirely of straight lines, that, when spotted as explained in connection with Figs. 6 and 7 of the text, can be made interesting and complicated. For instance, on looking at Fig. 10 of the text we observe that the pattern consists of two outline forms identical in every respect, and so shaped that one fits exactly into the other; that the lines *a* are all of the same length and at right angles to each other, and the lines *b* are all twice the length of lines *a*.

17. For Figs. 8, 9, and 10, draw with the **T** square three horizontal lines at *x*, *y*, and *z*, about $\frac{5}{8}''$ apart. Fig. 8 is then executed by drawing a freehand vertical line *x z* across the three lines thus ruled; and at a distance to the right of this vertical, equal to the space between the horizontals, another vertical line *u t* is drawn between the two lower horizontals. A third vertical line *w v* is then drawn the same distance to the right of the second one, and extending between the upper two lines. The horizontal lines *x w* and *u v* are then drawn, connecting the ends of *x z* and *w v*, and *w v* and *u t*, as shown, and with *t s* equal to *x w* the outline of one of the sections of the fret is complete. The vertical line *a'*, drawn to the right of *w v*, will then start a second section of the fret, and, at the same time, complete the inverted outline that is to follow the contour of the first section. A peculiarity of all the best Greek frets is that the outline of the fret and the outline of the background are identical, as shown in Fig. 10 of the text. Having drawn the meandering outline of the fret, draw the horizontal border lines above and below, so as to make the whole figure $2\frac{1}{2}''$ high. It is not necessary to erase the construction lines.

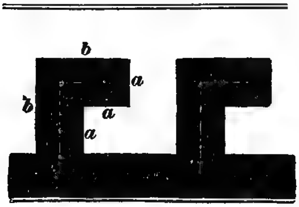


FIG. 10

18. Fig. 9 is somewhat similar to Fig. 8, but is capable of more variations in spotting, as shown in Fig. 11 of the text. At (*a*) we have the ground and the pattern of the fret spotted in contrasting colors, while the effect at (*c*) is produced simply by increasing the weight of the constructive lines. Both systems produce frets wherein the ground and pattern are similar in outline. At (*b*), the line of separation between the dark and light portions of the design is thickened into a white band and the other elements are left in black. To draw Fig. 9, a number of perpendicular lines are drawn across the center line *y* equal in length and spacing to the distance between the three horizontal guide lines *x*, *y*, and *z*. The tops *r* and bottoms *q* of each alternate pair of the verticals are then connected with a horizontal line equal to the verticals. This forms the meandering outline of the figure. Above and below this meandering outline, at a distance equal to half the space between the lines, two horizontal lines are drawn, from which perpendiculars extend into the open parts of the meander as far as the middle horizontal guide line *y*. The border lines above and below are then drawn to make the entire figure 2½″ high.

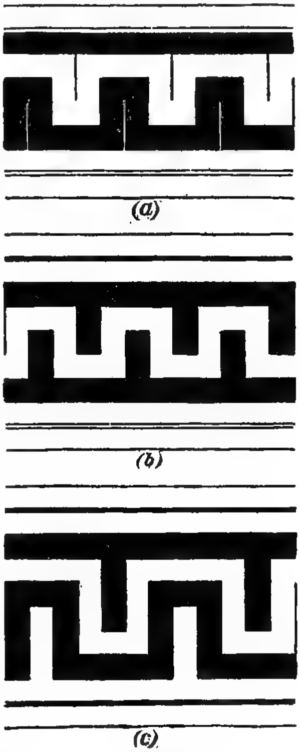
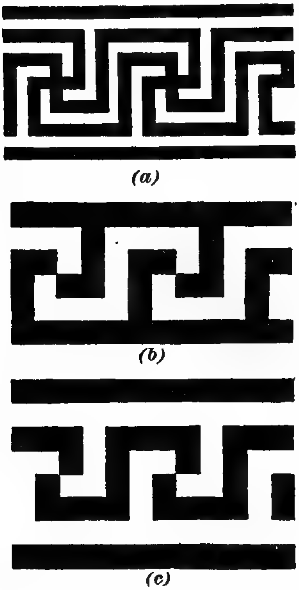
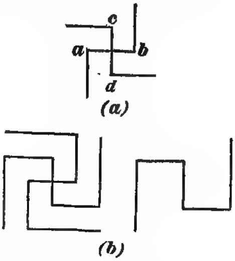


FIG. 11

19. Fig. 10 is more complicated. It is a combination of Figs. 8 and 9, and when analyzed shows two distinct but identical outlines so interwoven as to form one harmonious design. This design may be made very complicated by spotting, as shown in Fig. 12 of the text. None of the frets on the exercise sheets are to be spotted; they are to be left in outline.

To draw Fig. 10 of the exercise, the simplest method is to draw across the central guide line a short vertical line equal in length to the verticals in Fig. 9; then, through the center of this vertical, draw a horizontal line of the same length, thus forming a simple cross, *a b*, *c d*, Fig. 13 (*a*). Now, from the upper and lower ends of the verticals, draw lines of equal length to the left and right, respectively, and from the left and right of the horizontal line draw at right angles a line extending below and one above the center guide line and equal in length to the other lines drawn; this will produce a figure similar to Fig. 13 (*a*). Now draw a third set of lines at right angles to this second set and parallel to the first set, as shown in Fig. 13 (*b*). These lines are the same distance apart, and are exactly parallel. The horizontal lines at the top and bottom may now be extended to left and right, respectively, a distance equal to the space between parallel lines of the meander; this will complete one section, and the same operation may be repeated, making the intersections of the short cross-lines take place at a point five times the space between the horizontal lines to the right.


(a)
(b)
(c)
FIG. 12



(a)
(b)
FIG. 13

20. Fig. 11 is a simple octagon, but to draw it accurately requires more care and accuracy of eye measurement than any of the previous figures. Begin it by drawing a perpendicular line *a b*, about $2\frac{1}{2}''$ in length. Carefully lay off the length of *c d*, $1\frac{1}{4}''$ each side of *a b*; *e f* and *g h* are now drawn at an angle of 45° with *a b*, and intersecting it at its center *o*. From *o*, carefully lay off $1\frac{1}{4}''$ on each of the oblique lines, as its length each side of the center. If this work is accurately done, the lines connecting *a e*, *e c*, *c h*, etc. will describe a perfect octagon. Study it carefully, and if any signs of unevenness are observed, alter the outline and correct the point.

21. Fig. 12 is a circle, but it is drawn in precisely the same manner as the previous figure, except that the points *a e*, *e d*, etc. are connected with curved lines instead of straight ones. In drawing the circumference of the circle, after the guide lines have been carefully laid out, a short straight line may be drawn across the ends of each of the guide lines, as shown in Fig. 14 of the text at *a*; then between each pair of these short lines another short line may be drawn, producing a sixteen-sided polygon; the whole circumference may then be evened up as at *b*. Considerable practice is necessary to draw a perfect circle, but one will be surprised and delighted to learn how simple a problem this is after careful and repeated practice. After completing the figures, border line, etc., the title LINEAR ELEMENTS, exercise number, sheet number, date, name, class letters and number, etc. should be lettered in their appropriate places, as explained for Sheet I.

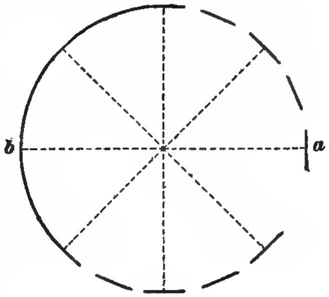


FIG. 14

22. **Exercise I, Sheet III,** includes Figs. 13 to 17. A horizontal line should be drawn $4\frac{5}{8}''$ above the lower border line dividing the plate into two horizontal bands. Bisect the upper one, and trisect the lower one; thus making five rectangles on the plate, in each of which its appropriate figure will be placed. Figs. 13, 14, and 15 are ellipses. The three large ellipses in these figures are each $4\frac{1}{4}''$ long and $2\frac{1}{2}''$ wide and the fourth one, intersecting the large one in Fig. 15, is $4''$ long and $1''$ wide.

Exercise I *Title* *Sheet III*

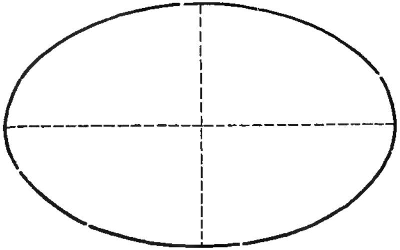


Fig. 13

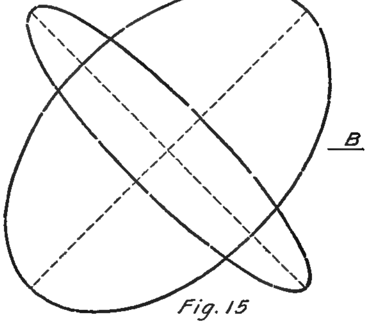


Fig. 15

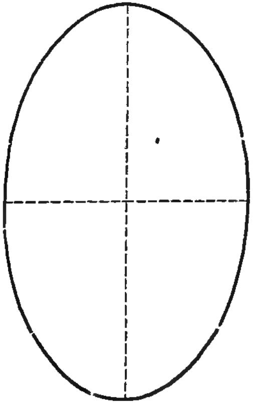


Fig. 14

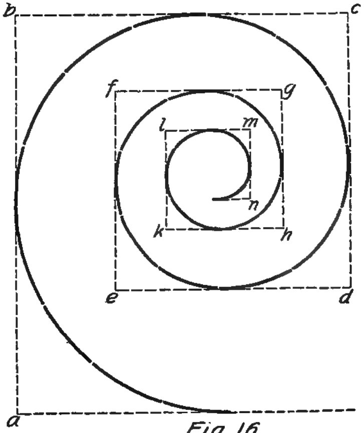


Fig. 16

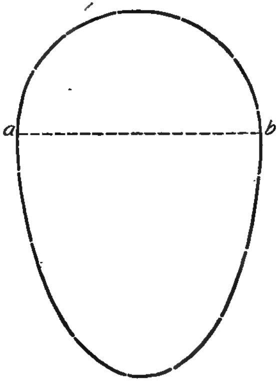


Fig. 17

Date

Time consumed in executing this sheet

Name of Student, Class Letters and Number

The method of drawing an ellipse geometrically was explained in *Geometrical Drawing*, so that the characteristics of the curve should be known by this time. First draw the two axes, then draw short straight lines at right angles to the ends of the axes, and roughly sketch in the curve, in pencil, as shown in Fig. 15 of the text. Care must be exercised, however, to keep the proper curvature and avoid such sketches as those shown in Fig. 16 of the text. It is easily seen that these are not ellipses, and drawing sheets must not be returned with any such monstrosities. This is a difficult figure to draw, but with proper care and practice it can soon be satisfactorily rendered. The construction lines of Figs. 11 to 15 should be drawn freehand.

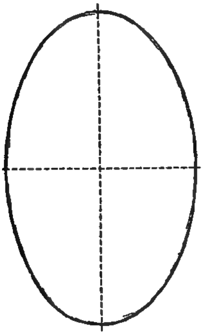


FIG. 15

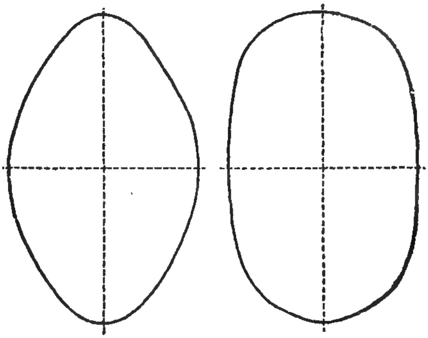


FIG. 16

23. Fig. 16 is a volute more commonly known as a spiral, and its outline in varied forms pervades all styles of ornament; it is therefore worthy of considerable attention. The example here given is purely Greek in its proportions, and the ratio of its height to its width is governed by definite geometrical rules for each convolution or turn.

To draw the Grecian volute, the construction lines *a b*, *b c*, and *c d* must first be laid out in the proportions shown, and succeeding construction lines in the same proportions. These proportions of the lines are those that have been accepted by students of classic architectural orders as governing the most graceful Grecian volutes.

The actual dimensions of the various construction lines should be laid out as follows: $ab = 4''$, $bc = 3\frac{3}{8}''$, $cd = 2\frac{3}{4}''$, $de = 2\frac{3}{8}''$, $ef = 2''$, $fg = 1\frac{11}{16}''$, $gh = 1\frac{3}{8}''$, $hk = 1\frac{3}{16}''$, $kl = 1''$, $lm = \frac{27}{32}''$, and $mn = \frac{11}{16}''$.

Within these construction lines (which must be accurately laid off with the scale, and drawn with the **T** square and triangle), the volute is then drawn freehand, care being exercised that the curves are just tangent to the straight lines as they pass. To prevent the curves from being flat, or from being sharp and oval shaped, where they touch the construction lines, draw them from the inside, using the wrist as a pivot, and turning the paper whenever necessary. Such a method will give the most graceful curves.

24. Fig. 17 is an oval and is composed of a semicircle and a semiellipse. Draw freehand the line *a b* $2\frac{1}{2}''$ in length. Above this line construct a semicircle in the same manner as was done in Fig. 12, using *a b* as its horizontal diameter, and below construct a semiellipse after the manner practiced in Figs. 13, 14, and 15, with *a b* as the minor axis, which shall extend $2\frac{1}{2}''$ below *a b*. The correct outlining of these elliptic curves is of vast importance in the exercises that follow, and should be frequently practiced. After finishing the sheet, insert the title LINEAR ELEMENTS and other lettered details in the customary places.

25. **Exercise I, Sheet IV,** is laid out on a sheet 9″ × 12″, with border line 8″ × 11″. By a vertical center line and a horizontal center line, the plate is divided into four equal rectangles, which are occupied by Figs. 18 to 21, inclusive.

Fig. 18, though simple in appearance, is by no means easy to draw. It represents the radiation of lines from a point, a characteristic of the growth of some plants that is frequently taken advantage of in examples of ornamental design. To draw Fig. 18, first lay off the lines *a b* and *c d* as the major and minor axes of an ellipse identical with Fig. 14; then carefully outline this ellipse in pencil, and within it draw the radiating lines curved, as shown. Note

Exercise I Title Sheet IV

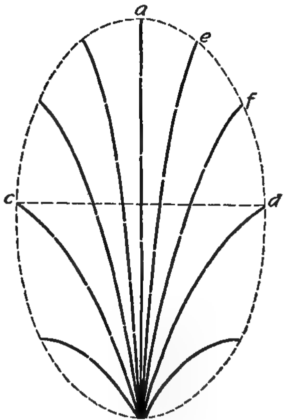


Fig. 18

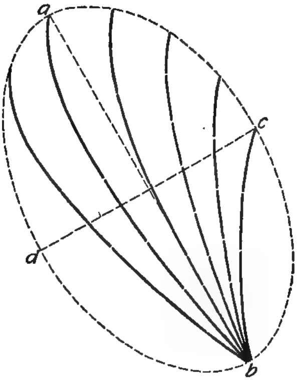


Fig. 19

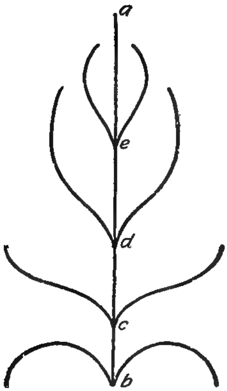


Fig. 20

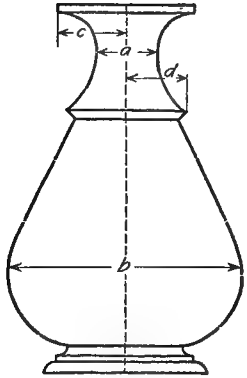


Fig. 21

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that the radiating lines intersect the circumference of the ellipse nearer together at the top than at the sides, *a e* being less than *e f* and *e f* less than *f d*. After completing the figure, the construction line *c d* should be erased, and the ellipse dotted in with the pencil and irregular curve.

26. Fig. 19 is drawn within an ellipse also, but the major axis *a b* is inclined at an angle of 60°. The curved lines radiate evenly from *b* and intersect the circumference in three points equally spaced between *a* and *c*. In finishing this figure, all construction lines should be erased except the elliptic curve from *c* to *a*, which may be dotted in with the pencil and irregular curve.

27. Fig. 20 is another example of radiation, but from a line in this case instead of a point. Draw *a b* 4″ long, and mark off thereon the points from which the curved lines radiate. Note that these points are not regularly spaced along *a b*, but that their distance apart increases toward the top. From *b* to *c* is about $\frac{5}{8}''$, while the distances *c d* and *d e* are nearly 1″ each. The radials starting from *c* extend $1\frac{1}{8}''$ to the right and left of *a b*, and upwards to the level of *d*. The radials from *d* extend $\frac{5}{8}''$ to the right and left of *a b*, and those from *e* only $\frac{3}{8}''$. Their length and upward extent must be judged by the eye, as also the two lower radials, which extend about 1″ each side of *a b*.

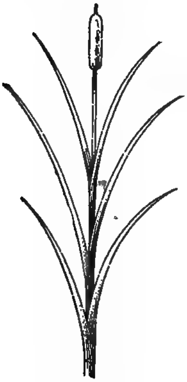

Fig. 17

These radiating figures must be studied carefully; there is really very much more in them than at first appears, and the principles of their composition and construction pervade all natural ornament.

The radiation of the lines in Figs. 18 and 19 is characteristic of the growth of some plants, such as the cattail, as shown in Fig. 17 of the text, and the veining of certain leaves, as in Fig. 18 of the text. The radiation from a line, as shown in Fig. 20 of the exercise, is characteristic of the growth of many trees and shrubs, and illustrates the great laws of all foliated ornament. These laws are based on the observation of the arrangement and natural growth of plants, and are as follows:

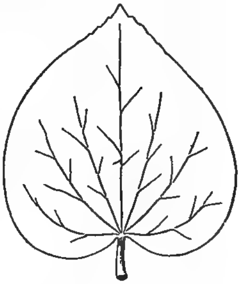

FIG. 18

1. *All lines should radiate from a parent stem.*

2. *All branching lines should be tangent to the line from which they branch,* as in Fig. 20, where the branching lines do not start out of *a b* abruptly, but are tangent to it at *c*, *d*, etc.

3. *There should be a proportionate distribution of areas.* This is not so easy to understand as the previous rules, but may be illustrated by a tree, wherein the areas are proportioned according to their distribution and distance from the parent stem. The trunk is the parent stem, and has the greatest area, but decreases toward the top. The branches nearest the ground are the largest and closest together, and diminish in size toward their ends. All branches and twigs are less in area than the branch from which they spring. In Fig. 20 observe that, though the parent stem and branches are single lines of equal thickness and apparent area, the arrangement is such as to give the impression of distribution. The area embraced by the lower branches is greater than that of the ones above, and the outline of the entire figure diminishes toward the top, giving an impression of lightness and solidity.

Always observe these rules in drawing any figure, and try to make the representation of an object appear lighter toward the top. Note that in all works of architecture, high structures, such as steeples and towers, are either made smaller toward the top, or are pierced above with large windows in order to give the appearance of lightness at the top and solidity at the bottom. Note that columns, pilasters, and piers are nearly always smaller at the top than at the bottom, thus expressing their immovability; while the legs of tables and other unfixed objects are smaller at the bottom than at the top, expressive of their movability.

28. In drawing Fig. 21, simply combine the details of a few of the previous problems. This figure is a vase 4″ in height, and $\frac{5}{8}$″ and $2\frac{1}{2}$″ in diameter at *a* and *b*, respectively. Draw the center line of the vase and lay out the outline entirely freehand and by eye measurement. Knowing the dimensions *a* and *b*, the observing student will discover that *c* is a little more than *a*, and that *d* is a little less. Other dimensions can be judged by comparison in the same manner and the figure completed without further directions. Letter the title LINEAR ELEMENTS at the top of the sheet, and place the other lettering at the proper places.

All the drawings should then be looked over carefully and compared with the full-page illustrations on pages 10, 21, 26, and 29, to see whether the student has done his best in drawing the figures, both as to actual proportions and as to neatness of execution. If there are any figures or parts of figures that the student believes he can improve upon, corrections and improvements should be made before sending the work to us. We do not want students' practice work on these exercises; we want their final very best work—work that is done to the best of their ability after practicing faithfully.

The four sheets of Exercise I, LINEAR ELEMENTS, should then be placed flat in the large envelope, stiffened with the cardboard, and mailed at first-class postal rates to the Schools for examination. This work will be returned as promptly as possible; and for this reason the student should not be unduly impatient about getting it back. He should concentrate his attention in making a start on Exercise II, title: Surfaces and Solids.

EXERCISE II, TITLE: SURFACES AND SOLIDS

29. The figures of Exercise II consist of a series of objects, the drawing of which will involve all the principles learned in the execution of Exercise I. The first four figures are designs of surface ornament or details wherein the consideration of depth or thickness forms no part. The remaining

Exercise II　　Title　　Sheet I

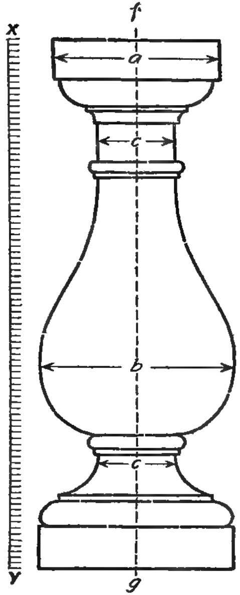

Fig. 1

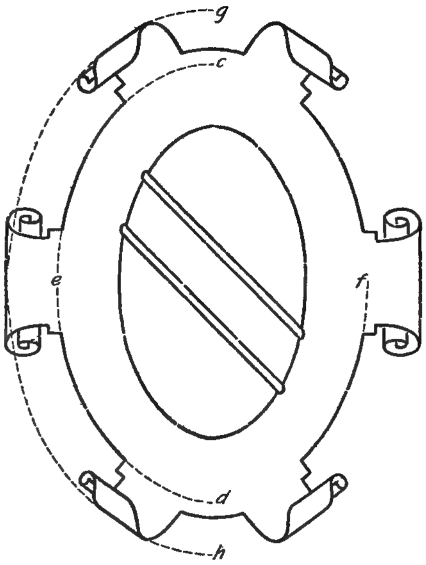

Fig. 3.

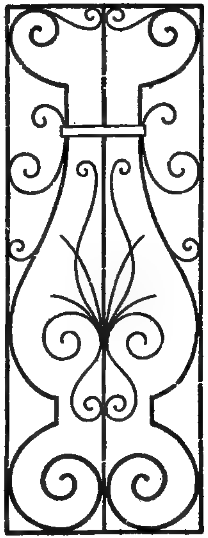

Fig. 2.

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figures will be sketches of familiar objects drawn so as to accustom the student to the representation of objects where the dimension of thickness or depth must be expressed in elevation or perspective.

Exercise II will consist of four sheets, outside measurement 9″ × 12″, and 8″ × 11″ within the border, as before. The first three sheets will consist of Figs. 1 to 7, but on the fourth sheet the option is given the student of working out the iron-strap work on Sheet IV (*a*), the iron knocker and lantern on Sheet IV (*b*), or the lamps and basket on Sheet IV (*c*). This variety is given that the one may be drawn that is most suitable to the taste. There is no objection to the drawing of more than one of these three sheets if it is desired, and in the correction of the work, it may be required that some of the other figures be drawn if the sheet selected is not worthy of a passing mark. It is always better to do too much freehand drawing than too little, as subsequent work will require a considerable knowledge of freehand handling, and the more practice one gets in this branch the better.

30. Exercise II, Sheet I.—The center line of Fig. 1 will be $2\frac{1}{8}''$ to the right of the left-hand border, and that of Fig. 2 will be $1\frac{3}{4}''$ to the left of the right-hand border. Fig. 3 will then be drawn midway between.

Fig. 1 is a baluster with moldings, according to the architectural proportions set forth for such details. First lay off with the scale rule a vertical measuring line $x\,y$, $\frac{1}{2}''$ to the right of the left border. This line will be divided into eighty-eight equal parts, as shown, each of which is $\frac{1}{16}''$, making the height of the baluster $5\frac{1}{2}''$. All the measurements for the proportioning of the baluster will be given in parts, each part being, as above stated, $\frac{1}{88}$ of the total height. The width of the abacus *a* is twenty-eight parts, the thickest part of the baluster at *b* is thirty-two parts, and the diameter of the neck at *c* is twelve parts. The vertical measurements can be determined by counting the number of parts between each division, and when all the horizontal lines are located the contour may be carefully sketched in. Although these proportions are subject to slight relative alterations under different circumstances, they are practically uniform in nearly all cases where the outlines of a stone baluster are required.

31. Fig. 2 is a panel of an iron railing, the design of which consists of a series of scrolls and radiating ornament, based on the outline of the baluster just drawn, but changed to suit the circumstances required by working in strap iron, in contrast to the requirements of stone. Attention is called particularly to the fact that there is propriety in the ironwork design in making its outline resemble the outline of the solid baluster, inasmuch as it is to serve a similar purpose in a balustrade of different material. The contour of the inside ironwork follows as closely as possible the contour of the stone baluster.

32. Fig. 3 is a design for another device in ironwork, but one of an entirely different character, being a cartouch made of sheet iron, the design of which is based on the ellipse. *Cartouch* is the term applied to circular, oval, or shield-shaped devices, whose surface is represented in relief, and the border of which is usually more or less ornate with scrolls or strap work. In order to understand the character of Fig. 3, study Fig. 19 of the text, which is a developed outline of the piece of sheet iron or other metal from which the cartouch would be made. The wings *a* are rolled backwards and the wings *b* rolled forwards, and produce the effect expressed in Fig. 3 of the drawing plate. Lay out the figure first, as shown in the text, and cut it out of heavy paper or thin metal; then by rolling the wings

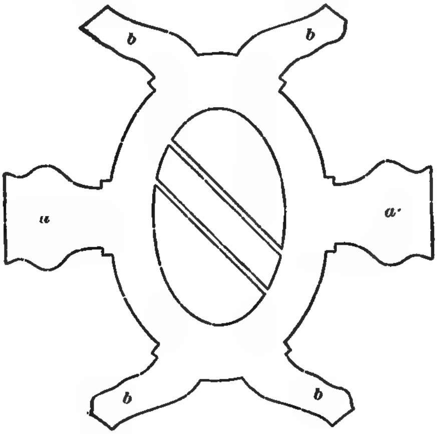

FIG. 19

Exercise II *Title* *Sheet II*

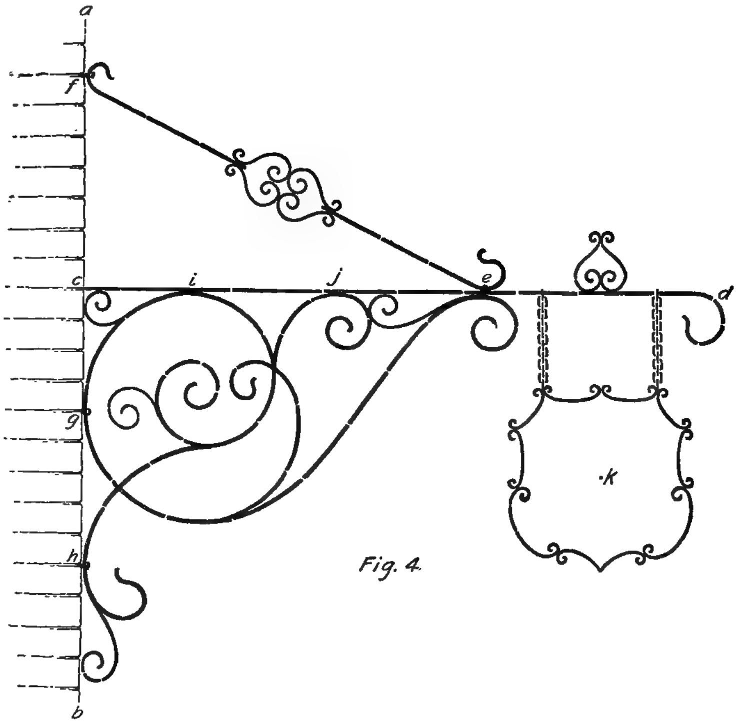

Fig. 4.

Date *Time consumed in executing this sheet* *Name of Student, Class Letters and Number*

around a pencil in the direction indicated, form a model of the device; when set up before you, this will greatly assist in the representation on the exercise. The length of the ellipse from *c* to *d* is 4½″, while its breadth from *e* to *f* is 3¼″. The interior ellipse is 3¼″ × 2″, the circumference of which is practically parallel with the outside. After the wings have been rolled over, they project uniformly from the top and sides of the cartouch, so as to come within the outline of another ellipse shown dotted at *g h*. There is nothing difficult in the drawing of this figure, the ellipses being contoured in the same manner as in Exercise I, Sheet III, and the curled wings being represented by a simple combination of scrolls and straight lines. It is not necessary to erase the guide lines.

Cartouches are not only executed in metal work, but are often carved in stone or wood, or modeled in plaster or terra cotta. They are also sometimes drawn, as in this exercise, as an ornament at the top, or in the center, of some certificate, or other paper of a documentary character. Its purpose, in nearly all cases, whether carved in stone or wood, or drawn or printed on paper, is to bear a device—either a number, a title, or a monogram. There are many forms of it, some being regular, as in this case, and others being irregular and eccentric, according to the purpose for which it is required.

It is not necessary to erase construction lines. Draw the border line and carefully letter the title SURFACES AND SOLIDS, and the other required lettering, in the accustomed places.

33. Exercise II, Sheet II.—In Fig. 4, which occupies the whole sheet, we have an iron bracket, such as is used in many cities as a sign hanger. It consists of straight and curved iron rods bent into scrolls, combining beauty of curve with utility of purpose. The main rod of the bracket *c d* is 6¾″ long. At *e*, 4¼″ from *c*, a hanger extends to the main wall at *f*, 2¼″ above *c*, while from the same point *e* on the under side of the rod *c d* the main scroll springs and becomes

Exercise II *Title* *Sheet III*

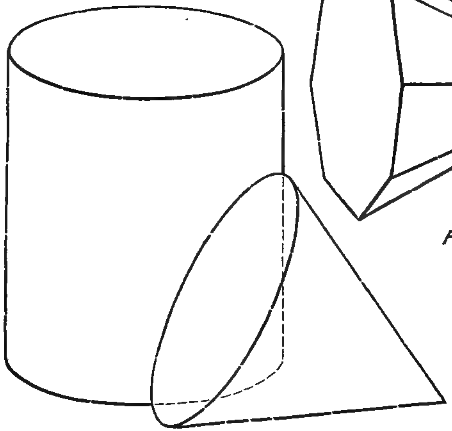

Fig. 5

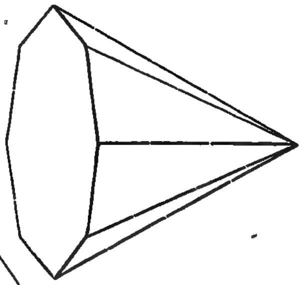

Fig. 6

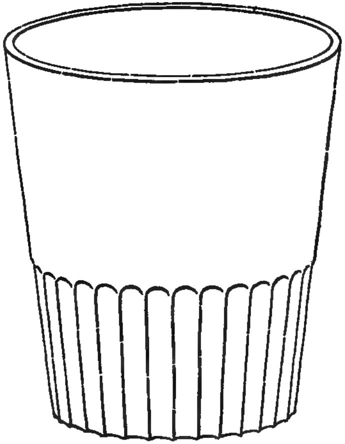

Fig. 7

Date *Time consumed in executing this sheet* *Name of Student, Class Letters and Number*

tangent to the wall at *g*, $1\frac{3}{8}''$ below *c*. The branch scroll is tangent to the wall at *h*, 3″ below *c*, and the other tangent points at *i* and *j*, $1\frac{1}{4}''$ and $2\frac{3}{4}''$ to the right of *c*, respectively. The other curves of the scroll, and the small ornamental scrolls on the top and sides of the main bar and hanger, can be proportioned and drawn by the eye, altering and shifting them as the circumstances may dictate. The sign itself (not including the chains) hangs below the bar within a rectangle 2″ square, the center of which is at *k*, $5\frac{1}{2}''$ to the right of the wall and 2″ below the bar *c d*. The rectangle containing the sign should be drawn in place and the sign sketched within it. After the figure is drawn all the guide lines may be erased. Take plenty of time and pains in drawing this figure, as its style is not only useful for many devices and designs, but the same design will be used later to illustrate an advanced branch of ornamental iron work. Draw the border line and letter the sheet as usual.

34. Exercise II, Sheet III, includes Figs. 5, 6, and 7, which are sketches of objects in perspective. While it is not the intention in this Section to teach the theory of perspective drawing, there are a few simple details concerning perspective representation that are not only useful, but in some instances of design positively necessary. In the first place, the appearance of a circle in perspective is always elliptic, and when one draws an ellipse, either mechanically or freehand, he represents thereby the perspective view of a circle. Practice frequently the drawing of ellipses of different sizes, and particularly of different widths on the minor axis; for instance, start, say, with a circle 3″ in diameter and then draw an ellipse $3'' \times 2\frac{1}{2}''$ and another $3'' \times 2''$, thus decreasing the length of the minor axis and maintaining the same length of major axis until this diminishing circle reaches the limit in a straight line. Having done this, draw inside of the circle some polygon, as shown in Fig. 20 (*a*) of the text, either an octagon or a hexagon, or even a triangle, and then project horizontally across from the circle, through all the ellipses, lines marking the corners of the polygon where they intersect the circumference of the circle. Short straight lines, connecting successively these points in the circumferences of the ellipses, will give a perspective view of the polygon inscribed in the circle, as shown at (*b*), (*c*), etc.

35. Fig. 5 of this exercise is a perspective view of a cylinder and a cone, the former standing on its base and the latter lying on its side. The top of the cylinder is an ellipse $3'' \times 1''$, and the bottom is a semiellipse of the same size. The height of the cylinder is $3\frac{1}{4}''$, and straight lines connecting the extreme outside points of the ellipse and the semiellipse complete the drawing of the cylinder and represent it as it would appear in perspective. To execute the perspective view of the cone, locate a point $1\frac{3}{8}''$ below the right-hand end of the longitudinal axis of the ellipse forming the top of the cylinder. Locate another point $\frac{1}{4}''$ below the base of the cylinder and $\frac{1}{4}''$ to the right of its axis. Connect these two points with a straight line. On this line, an ellipse $3''$ long by $1''$ wide is then drawn, similar to the ellipse forming the top of the cylinder. From the center of this ellipse draw a line $2\frac{1}{2}''$ long perpendicular to its major axis, and consider this line as the

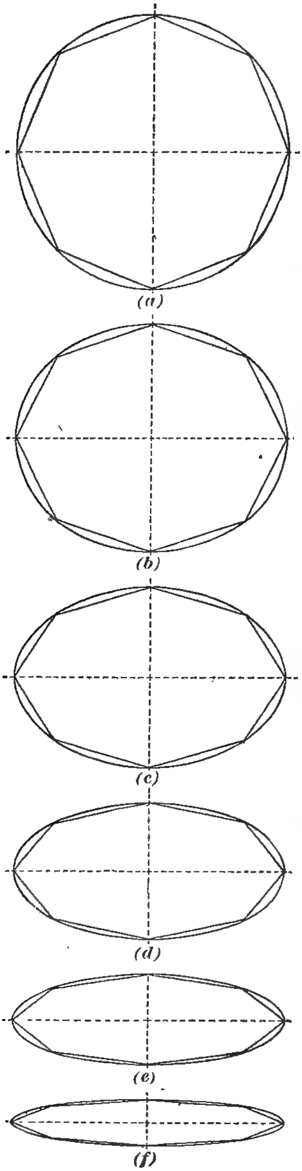

FIG. 20

axis of the cone. From the right-hand end of this line draw two lines tangent to the curve of the last ellipse, as shown, these lines forming the sides of the cone. This will complete the view of the cylinder and cone in perspective, and the portion of the cylinder that extends behind the cone, which is shown dotted in the drawing, should then be erased.

36. Fig. 6 represents an octagonal pyramid. The base of the pyramid shows an octagon in perspective, which is drawn within an ellipse 3″ high by 1″ wide. Perpendicular to the major axis of this ellipse a line is drawn $2\frac{1}{2}$″ long, which is the axis of the pyramid, and from the right-hand end of this line, straight lines are drawn connecting the corners of the octagon with the apex of the pyramid, thus representing that figure in perspective.

37. Fig. 7 is a perspective view of an ordinary tumbler, which, though slightly more complicated, and thereby demanding greater care in execution, is no more difficult to draw than either of the previous figures. The top of the tumbler is an ellipse $3\frac{1}{2}$″ long by 1″ wide, and the bottom is one-half of a regular thirty-sided polygon drawn within an ellipse $2\frac{1}{2}$″ long by $\frac{3}{4}$″ wide. The distance between the major axes of the two ellipses is 4″, and the sides of the tumbler are drawn tangent to the extreme ends of the curves. Above the bottom of the tumbler, about $1\frac{1}{2}$″, a third ellipse is drawn lightly, to indicate the point where the fluting starts. Within the two lower ellipses two semipolygons are drawn in perspective, each with fifteen sides. These semipolygons should first be laid out in a semicircle above and below the major axes of the two lower ellipses, as shown in Fig. 21 of the text, and the points of intersection of their sides with the semicircle projected to

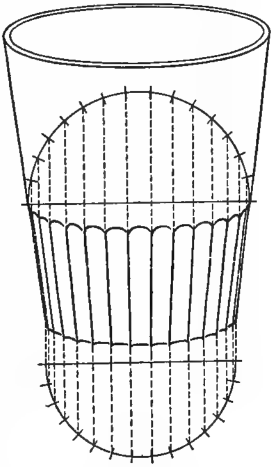

FIG. 21

the ellipses of the tumbler, in order to locate the points to draw the polygon in perspective. The subdivisions of the semi-circumference may be laid off by setting the legs of the dividers at a distance approximately correct, and then "walking" them along the circumference. It will be observed that this figure is simply a combination of the essential points of the two previous problems. This sheet should be finished and properly lettered, as were the previous sheets.

38. Exercise II, Sheet IV (*a*), consists of four figures all suggestive of elements of ornamental strap ironwork. Fig. 8 is a horizontal grille or border and should be constructed within a rectangle $1\frac{5}{8}'' \times 10''$, the top of the rectangle being $\frac{5}{8}''$ below the top border line. To draw Fig. 8, the rectangle should be carefully laid out, and the first scroll from the left end carefully sketched in. The points where this scroll becomes tangent to the top and bottom lines of the rectangle should be on the same vertical. From this lower point of tangency draw, with the 30° triangle, a diagonal line upwards and to the right through the figure, marking the upper point of tangency of the second scroll; another diagonal, at 30°, downwards and to the right from this last point will mark the tangent point of the third scroll; etc. With these lines as guides to the construction, carefully sketch in the main wave line of the scroll throughout the length of the rectangle. Carefully complete the scroll that forms the left end of the panel and with a soft sharp pencil trace it on a piece of tracing paper or cloth. Then turn over the tracing and after adjusting it in position for the second scroll go over the lines with a hard pencil as they show through the tracing and thus transfer the design to the second place. Repeat this operation for the third and fourth scrolls and then carefully finish the figure with a 2 H or a 3 H pencil.

Figs. 9, 10, and 11 are drawn in rectangles $4\frac{1}{2}''$ high; Fig. 9 is $4''$ wide and Figs. 10 and 11 are each $2\frac{5}{8}''$ wide. Each of these figures represents the same design in iron grille-work. Fig. 9 shows the pattern as a flat surface in

Exercise II *Title* *Sheet IV (a)*

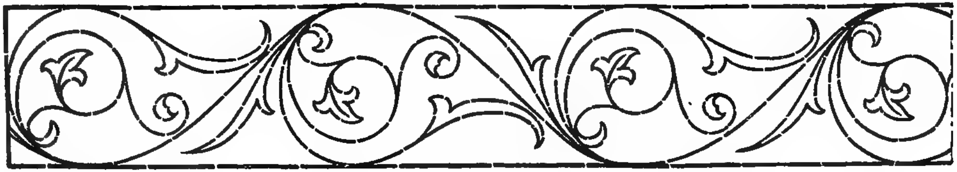

Fig. 8

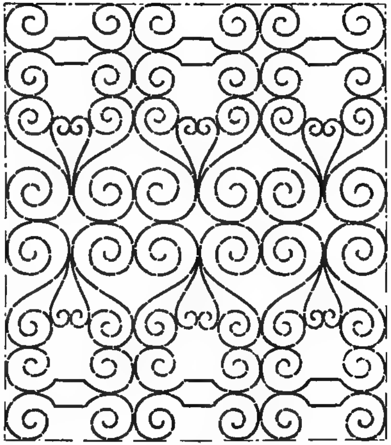

Fig. 9

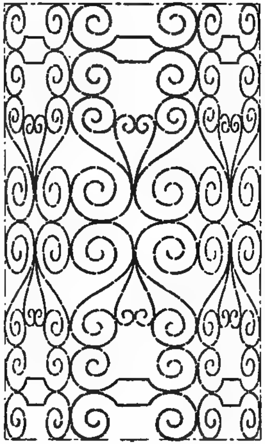

Fig. 10

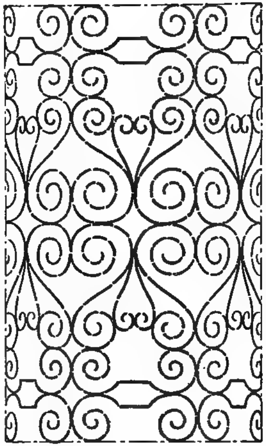

Fig. 11

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three vertical panels; Fig. 10 shows it as it would appear if bent around three sides of a hexagonal prism with each side corresponding to one panel of the grille; and Fig. 11 shows it as it would appear bent into a semicylinder. Draw the three rectangles according to the above dimensions and then divide Fig. 9 into three equal vertical panels. Draw a horizontal line through the center of all three panels, and another horizontal line $1\frac{1}{4}''$ above and below the center line. Sketch in one of the scrolls in Fig. 9, then trace it on paper, and reverse the paper so as to transfer it in some other place. Repeat this operation until the design is complete. Carefully strengthen the design with a sharp pencil and complete the figure as shown.

Fig. 10 is also divided into three parts but these parts are not equal. On the bottom line of Fig. 10, describe a semicircle with the width of the rectangle as its diameter. From the extremities of this diameter describe arcs, equal to the radius, intersecting the circumference. Construct thus a semi-hexagon. Draw vertical lines through the angles of the hexagon, thus completing the elevation of a hexagonal prism. On the middle face of this prism draw the design as it appears in the panels of Fig. 9. On the two adjoining faces, draw the design foreshortened in width to fit the narrower spaces of the receding sides of the hexagon.

On the base of the rectangle, Fig. 11, draw a semicircle; divide the circumference of this semicircle into nine equal parts. Through these points of division draw vertical lines through the rectangle and construct the foreshortened view of the grille-work as it would thus appear bent into a semicylinder.

Complete the figures carefully and place the title SURFACES AND SOLIDS and other lettered details in their proper places. In place of this sheet, IV (*a*), either of the next two may be executed.

39. Exercise II, Sheet IV (*b*).—On this sheet are shown two figures, one of an ornamental iron-bar knocker, and another of an ornamental sheet-metal lantern. The center

Exercise II

Title

Sheet IV (b)

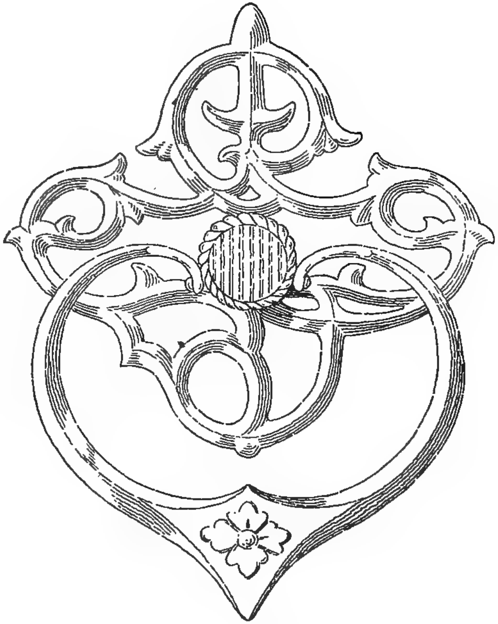

Fig.1

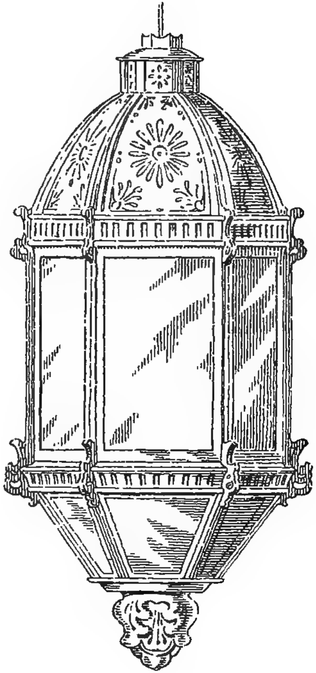

Fig.2

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line of Fig. 1 is 3″ to the right of the left-hand border line, while the center line of Fig. 2 is 2½″ to the left of the right-hand border line. These center lines should be drawn first, and the other details worked out from them. The total height of Fig. 1 is 6½″; this height should be laid off on the center line. A horizontal center line should be drawn at right angles to the vertical one, about 4¾″ or more long. The circular boss about the center of the knocker is exactly 1″ in extreme diameter, and is above and tangent to this horizontal line.

In constructing this figure it will be advisable to lay out an irregular hexagon to bound it. Two angles of the hexagon will be at the top and bottom of the figure, and the two sides can be located 2⅜″ each side of the center line. The lengths of these sides should then be laid off 1¼″ above and below the horizontal center line, making them each 2½″ long. Lines drawn from the sides so formed, to the top and bottom points of the figure, will construct an irregular hexagon within which the principal details of the figure may be formed. The large lower curves will be tangent to two sides of the hexagon, and the two large lower curves of the knocker and the outside curves of the wall piece of the knocker will extend somewhat beyond the sides but be tangent to the upper lines of the hexagon.

The construction lines as described can be laid out on the illustration of Exercise II, Sheet IV (*b*), given on page 44, and the other details located therefrom. Any desired measurements may be taken and transferred, as the finished drawing is to be about twice the size of the illustration, as is the case in all of the examples of freehand drawing herewith given. Great care must be exercised in shading this figure in order that the lines may not run into each other and cause dark spots. These shade lines must be drawn very slowly, as described for Exercise I, Sheet I, and kept parallel.

Commence drawing Fig. 2 by laying out a rectangle 1⅛″ wide and 2″ high as the central light of glass in the lantern. The bottom of this rectangle will be 2⅜″ above the extreme

Exercise II *Title* *Sheet IV (c)*

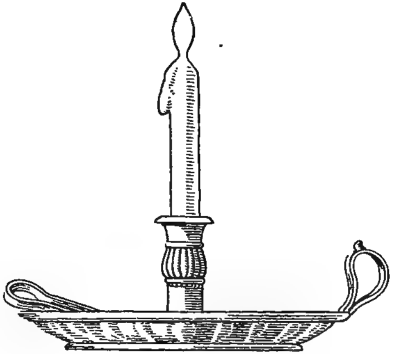

Fig.1

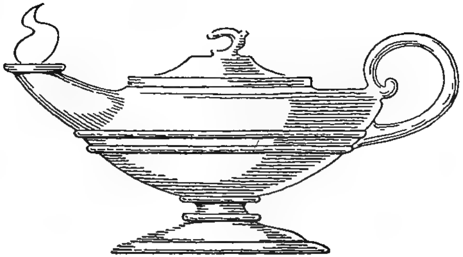

Fig.2

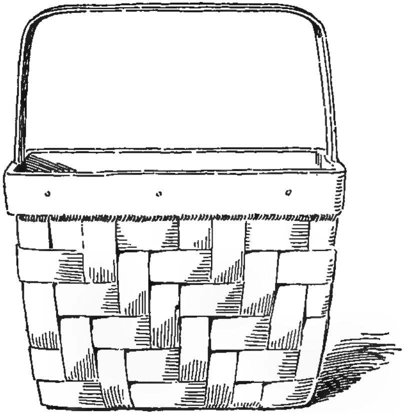

Fig.3

Date

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lower point of the ornament on the bottom of the lantern, and the total height of the lantern on the center line from its ornament to the top of the cap is 6¾″. Having located the bottom of the boss, or ornament, hanging below the lantern, measure up on the center line 1″ and draw a horizontal line locating the bottom of the slanting portion; 1″ above this, another horizontal line will mark the top of the slanting portion; 3″ above this, another horizontal line should be drawn locating the commencement of the curved portion; and one above this 1¼″, where the top of the curved dome unites with the cap, which latter is ½″ high. With these points located and the 1⅛″ × 2″ rectangle indicating the glass light, the details of the central section of this lantern can be carefully worked out. The details of the two side lights can then be worked out. Assume the central portion of the lantern to be the elevation of a regular hexagonal prism, then the two side lights represent the receding sides. Above or below the lantern construct a hexagon whose sides will be 1⅛″ each, and project from this hexagon lines into the drawing to get the width of the side lights and accessories. Finish up the drawing and shade it as shown, taking every precaution mentioned in connection with Fig. 1. Place the exercise number and sheet number at the top, together with the title SURFACES AND SOLIDS, and the date, name, class letters and number, and time occupied, in their usual places at the bottom of the sheet.

In place of this Sheet IV (*b*), the next one, Sheet IV (*c*), may be executed.

40. Exercise II, Sheet IV (*c*).—On this sheet are to be drawn three simple figures, two in elevation and one in parallel perspective. These figures are every-day objects and are likely to be found useful in several schemes for simple drawings and designs. The center line of Figs. 1 and 2 is 3″ to the right of the left-hand border line, and the base of Fig. 1 is 4″ above the lower border line, and that of Fig. 2 is 1″ above. Locate Fig. 1 by drawing a horizontal line through its center line representing the base. Make this horizontal line 4″ long, or 2″ each side of the center line.

Above it lay off $3\frac{1}{2}''$ on the vertical center line, and from the points so located draw lines to each end of the base line. A triangle $4''$ wide and $3\frac{1}{2}''$ high will thus be constructed within which the figure should be drawn. The sides of the triangle will just touch the upper edge of the tray forming the bottom of the candlestick; the under side of the tray slants inward at an angle of 30°. The other details can be readily located after the main lines are constructed, and when the figure is shaded the lines should be carefully laid on, care being exercised to prevent them running together.

Fig. 2 is also drawn with a triangle to govern the construction lines for its contour, but in this case the triangle is inverted. First erect a vertical line $3''$ to the right of the left border line. Now, $1''$ above the lower border line, cross this vertical line with a horizontal line about $2\frac{1}{4}''$ long, which will serve as the base line of the lamp. $2''$ above this base line draw a horizontal line $5''$ long, and draw lines connecting its extremities with the center of the base line. This will form the desired inverted triangle. Now, $2\frac{9}{16}''$ above the base line, establish a center and with a radius of $2''$ draw a semicircle, the lower part of which will be tangent to the sides of the triangle and will form the contour of the body of the lamp. Draw a horizontal line $1\frac{3}{4}''$ above the base line to form the top line of the main body of the lamp. The lid or cover comes above this line. The remaining details can easily be sketched in.

Fig. 3 is located midway between Figs. 1 and 2 and the right border line. Its total height is $4\frac{1}{2}''$ to the top of the handle; the width of the basket at the bottom is $2\frac{3}{4}''$, and the width of the handle at the top between the vertical uprights of the handle is $3''$. The band around the top of the basket proper is $3\frac{1}{2}''$ long in front and projects its own thickness beyond the body of the basket. The effect of perspective is obtained by showing the back of the basket and its receding sides inside. Draw this as shown, shading very slightly, and indicating the basket-weave work. Letter the title Surfaces and Solids and the exercise and sheet number at the top, and the date, time consumed, name, and class letters and number at the bottom as usual.

Of these last three sheets, some will find the work more difficult on one than on the others, and care should be taken with whichever one is attempted. A careful study of the original must be made, so that the pencil drawing is entirely satisfactory before sending in the work.

Do not send us your drawing of this exercise for correction until after Exercise I, title: Linear Elements, is returned to you with corrections and criticisms. Then note carefully the errors pointed out and see that similar ones have not been made on your Exercise II, title: Surfaces and Solids. When any necessary corrections have then been made on your Exercise II, title: Surfaces and Solids, it should be sent to the Schools for correction; your attention being next given to Exercise III, title: Natural Leaves.

EXERCISE III, TITLE: NATURAL LEAVES

41. Exercise III consists of twelve figures, each representing some form of a natural leaf, and is to be executed in pencil, as in previous work. In making these pencil drawings, they should first be sketched carefully with a rather dull, hard pencil, thus making very light lines that can be easily erased for correction. Use no more pressure on the pencil than is required to make a visible line. When this outline is sketched satisfactorily, each leaf should be finished up with a somewhat softer pencil sharpened to a long, fine point. This pencil must be used very lightly, or the lines will become blurred in handling, giving the drawing a very untidy appearance. Too soft a pencil should be avoided; first, because it cannot be maintained at a sharp point, and second, because it will soil the drawing. The work on this exercise is intended to familiarize the student with the characteristics of each kind of leaf represented and to accustom him to the study of the botanical and geometrical details of all vegetable forms used in design. Studies from actual specimens of leaves and flowers are to

Exercise III *Title* *Sheet 1*

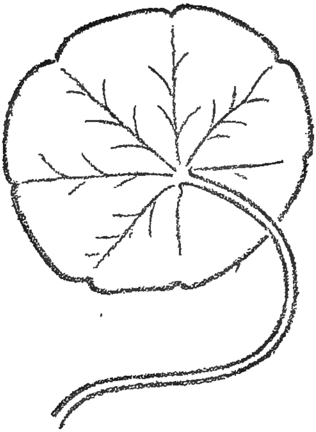

Fig. 1

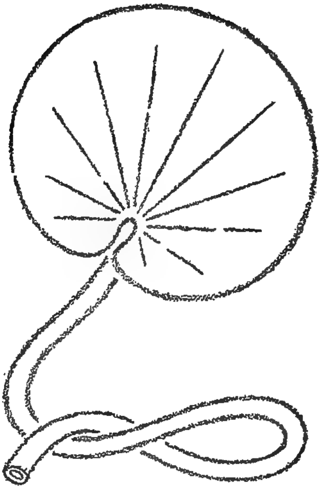

Fig. 2

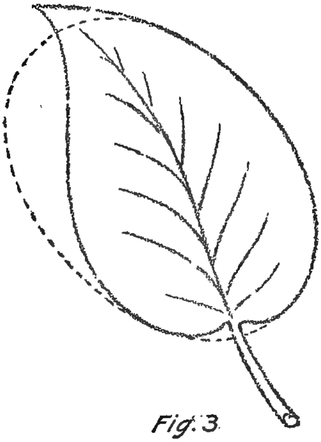

Fig. 3

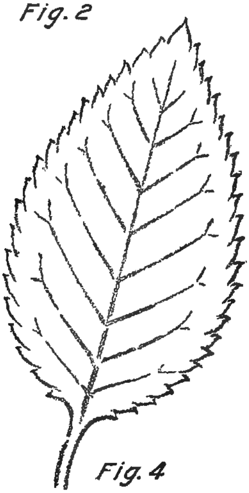

Fig. 4

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be preferred to those shown on the printed copies; these, however, should be supplementary to the regular exercises. Send regular exercises whether or not you send original studies. Nearly all leaves and flowers are governed in outline by some geometrical figure, and by varying this outline slightly, various leaf forms are made different, while the leaves are at the same time governed by the same geometrical figure.

42. Exercise III, Sheet I.—This sheet includes Figs. 1 to 4, and is laid out by dividing the plate vertically and horizontally by center lines, thus making four equal rectangles in which the figures are properly proportioned.

Fig. 1 is the leaf of the Nasturtium, the governing outline of which is a circle. First draw, lightly, a circle about 3″ in diameter, the exact dimensions being of no great importance. It will be observed that there are seven sides or lobes to the leaf, the lower one being the largest, and the others unequal. These lobes are expressed by making slight notches in the circumference of the circle and then rounding them off into the main curve. The stem joins the leaf not on the edge but at a point about one-third the way up, and from it radiate seven veins, each toward one of the notches in the circumference of the leaf. It will now be observed that two of these veins form an almost straight line across

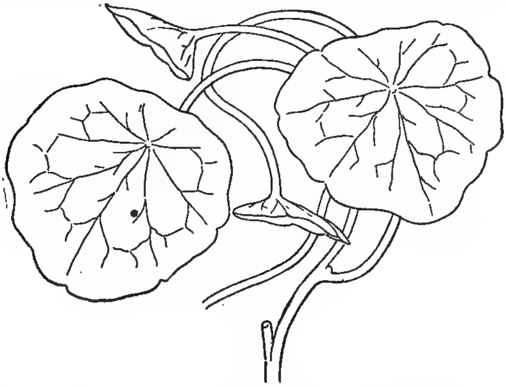


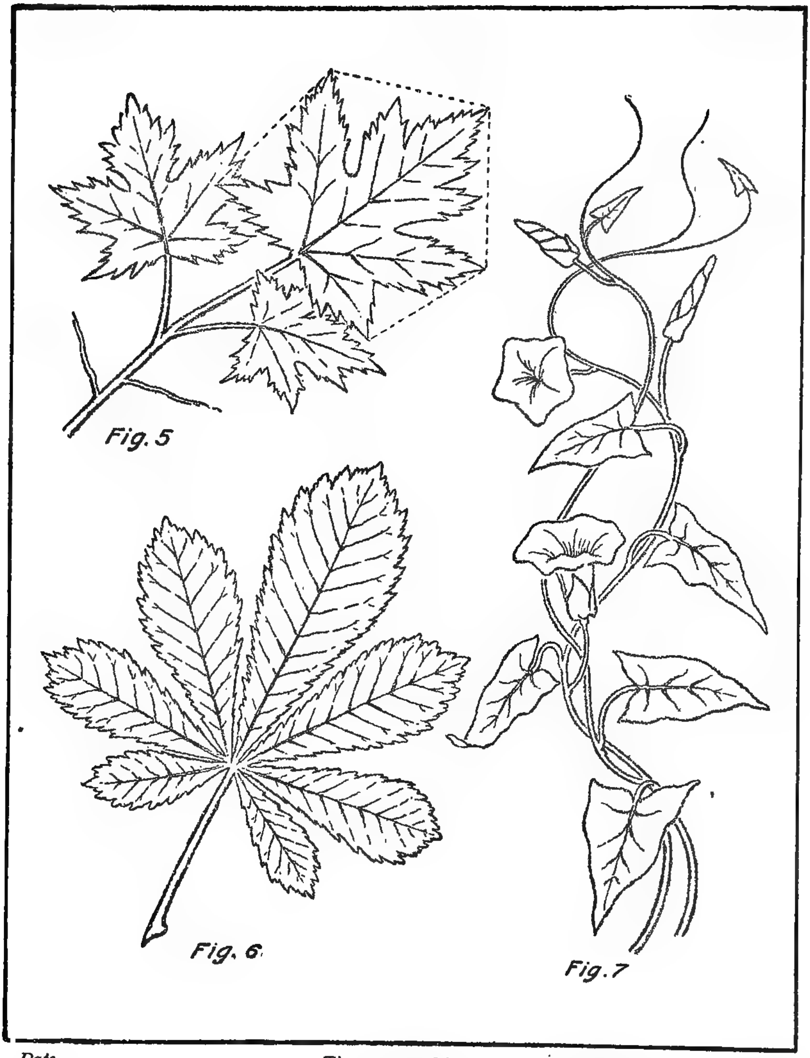
FIG. 22

the lower portion of the leaf, above which three of the veins radiate at almost equal angles. These are geometrical characteristics of the Nasturtium leaf, and if followed out will enable the student at all times to present a fair portrayal of this class of vegetation. When used for embroidery work and other classes of design wherein a softness of outline is more consistent with the character of the material, the leaf may be expressed more freely, as shown in Fig. 22 of the text. In drawing figures of this exercise, do not actually copy them. The work will not be judged according to the accuracy compared with the copy, but according to the clearness with which the object portrayed is represented. If it is possible to procure a Nasturtium leaf from the plant, make a drawing of that, using the characteristics in this description as a guide in the procedure. As has been said, "A drawing is the expression of an idea by means of a picture," and the work on these plant forms will be judged by the clearness with which an idea is expressed rather than by the accuracy with which a figure is copied.

Fig. 2 is a leaf of the pond lily; this also is based on the principle of the circle, but with an even circumference that is deeply indented at the bottom. At the point of indentation, a long stem joins the leaf, from which thin veins radiate toward the circumference. The length of the stem is a matter of little importance, as in nature it is governed by the depth of the water in which the lily is growing. In size the leaf may be the same or slightly larger than the Nasturtium leaf, and the stem may be curled as shown on the drawing; though if the drawing is made from the actual lily leaf, instead of this copy, the stem may be drawn as it is in the original.

The leaves shown in Figs. 3 and 4 are characteristic of a number of plants, and vary in size with each plant. Their governing outline is practically an ellipse, as shown by the dotted lines. Draw for them two ellipses about $3\frac{3}{4}''$ in length by $2\frac{1}{2}''$ in width, as shown by the dotted lines, and then draw one side of Fig. 3, corresponding closely to the circumference of the ellipse. The other side diverges from

Exercise III *Title* *Sheet II*



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Name of Student, Class Letters and Number

the ellipse as shown, the leaf being pointed at its upper end and slightly indented at the bottom. A long vein extends from the stem of the leaf, which joins it at the bottom indentation, almost to the point at the top, and the side veins branch to the right and left. After the drawing is completed, the construction lines may be erased.

The drawing of Fig. 4 is precisely the same as Fig. 3, except that the edges of the leaf are serrated or notched, as shown, and there is no indentation at the bottom, the leaf ending in a point at that end also, but more abruptly than at the top. This is the style of leaf characteristic of the rose and of the elm tree, though on the former plant it forms one of a group of leaflets, and is seldom more than half this size.

Having carefully completed the figures, draw the border line. Then letter the title, exercise number, sheet number, etc. in their accustomed places.

43. Exercise III, Sheet II, includes Figs. 5, 6, and 7. The spray of leaves in Fig. 5 is from the maple tree, and their governing outline is a pentagon, not a regular pentagon with equal sides, but one whose base is considerably longer than the other four sides. The indentations in the top lobe are more marked than those in the side lobe, and vary in different leaves; in fact, no two leaves are ever exactly alike, though the characteristics are always the same, and there should be no difficulty in portraying a maple leaf so that it is unmistakable for this class of vegetation. The lower lobes of the leaf are sometimes rounded, and in the younger leaves the indentations are much less marked than in the mature ones. In drawing the spray shown in Fig. 5, draw the large leaf first, and fit the smaller ones in under it, as shown, not necessarily following this exact arrangement, but placed in such a manner that they will show the characteristics of the leaf. Maple leaves are easily

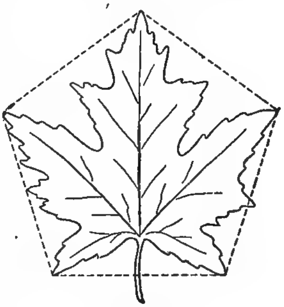

FIG. 23

obtained in nearly all communities, and the student should certainly draw this figure from nature, if possible. The maple leaf can be characteristically and conventionally designed within the sides of a regular pentagon, however, as shown in Fig. 23 of the text.

Fig. 6 is a cluster of one class of horse-chestnut leaves, the governing outline of which is practically a hexagon. Each leaf is complete in itself, but as they always grow in a cluster at the end of a stem, with almost invariably the same number in a bunch, it is proper that they should be so represented, especially in design, as this is one of the geometrical characteristics of their botany. The true horse-chestnut leaf has invariably seven leaves in a cluster, arranged in the same manner as this example, but there is another variety of the same tree that has either five or seven in a cluster. To draw Fig. 6, first construct a general outline of the group as explained on page 5, and then draw in the individual leaflets. The general outline will be somewhat the shape of a hexagon, with the outside points of the leaves and extremity of the stem in each of its angles. In drawing the leaves, observe that they are larger at their outer ends than toward the stem; that the notches in their edges extend into the leaf toward the stem, and are not sharp, straight lines, but curved in the same direction as the veins of the leaf. The last point at the extreme end of the leaf is considerably longer than the others, and tends to give a spear-like termination. The peculiar form of the leaves permits them to cluster nicely in a bunch, as shown, and enables them to be conventionalized and easily used in certain forms of geometrical designs.

The first six figures of this exercise will serve to familiarize one, as far as is necessary, with the geometrical and botanical characteristics of these particular forms. Make it a point, however, to study other forms, and broaden the knowledge as much as possible in the observation of nature. Frequently, draw the leaves of different plants, and if the drawing does not convey a satisfactory idea of the leaf itself, analyze it carefully, and also the natural leaf, and learn wherein some detail that stamps the character of the original has been altered or omitted. These leaves have been drawn singly because they are usually seen singly on the trees, or on the ground under the trees, with the exception of the horse-chestnut leaf; they are seldom associated in the mind as clusters. In the next six figures, however, a class of leaves is considered that are associated with the vine or plant on which they grow, and their characteristics must be considered, not singly, but together with the plant and surrounding details. Figs. 1 to 6 represent, also, a development in botanical evolution, the theory being that the fundamental leaf form was circular, as in Fig. 2. The notches in the outline of Fig. 1 are indicative of a lack of nourishment being conveyed to the margin of the leaf at certain points, thereby retarding its growth; the serrations in the edges of Fig. 4 are caused by a similar lack of circulation of sap, until finally we come to Fig. 5, where the serrations are so developed as to make lobes on the edges of the leaf, and in Fig. 6 to cause the leaves to grow in clusters at the end of one stem, instead of a single leaf. The different forms of the edges of leaves so developed are due to the system of veining. A study in comparison of different forms of leaves will soon place one in a position to judge and recognize the proper veining of a great many leaves, according to the indentation of their edges. The Nasturtium leaf is indented regularly at the end of each vein, and the veins are regular and straight. In the maple leaf, the indentations are very irregular, because the veining of the leaf is irregular and forms a network throughout the whole tissue. In the horse-chestnut leaf, the general veining is regular in each individual cluster, thereby causing an even subdivision into a uniform set of individual leaflets, while the edges of each leaflet are serrated, owing to a slight irregularity in their individual veining.

Fig. 7 is a spray of the vine and leaves of the Convolvulus, which is of the class of vine to which the morning glory belongs. Do not attempt to draw this until the drawing of the individual leaves of the plant have been frequently practiced on separate pieces of paper. The number of leaves on the stem will depend on the object being drawn. If it is possible to secure a slip of the vine itself, draw it as you see it, locating the leaves as you see them. Do not attempt to copy this exercise, but refer to it for the expression of the stronger characteristics of the growth. If a slip of the plant cannot be obtained, make the drawing from the plate. The leaves of this example are triangular, slightly indented at the bottom, and manifest a strong inclination to curl up slightly at the edges. They are a soft leaf, and rarely lie stiff and flat, like the maple. In drawing them, observe the character of the veining, the arrangement on each side of the main stem, noting that they branch alternately, and that no two of them start from the same point. The leaf that is turned over, showing its under side, indicates the method and manner of the stem joining the surface, and in making the drawing bear in mind that the governing principle is an isosceles triangle, as shown in Fig. 24, and that the arrangement on the stem is an alternation on opposite sides. Observe, particularly, that the stems of the leaves, where they branch from the parent stem of the plant, have a little knob or enlargement that marks the joint. This is also the case in Figs. 8, 10, and 11, and is rather more perceptible in the last two than in Figs. 7 and 8. This enlargement of the stem is characteristic of growing plants, and should be carefully noted in the drawing. The figures are left in outline as before, the border line and lettering being placed at their accustomed places.

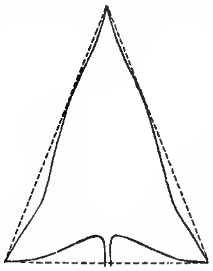

FIG. 24

44. Exercise III, Sheet III, includes Figs. 8, 9, and 10. Fig. 8 is a spray of ivy leaves, each of which may be drawn within a pentagon, as shown in Fig. 25 of the text, in the same manner as was described for the maple leaf. The edges of the ivy leaf are not serrated, and the sides of each lobe are distinctly curved. Each leaf has five lobes; the

Exercise III *Title* *Sheet III*

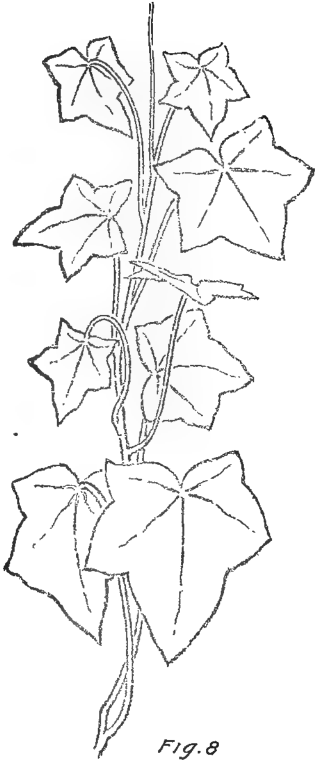

Fig. 8

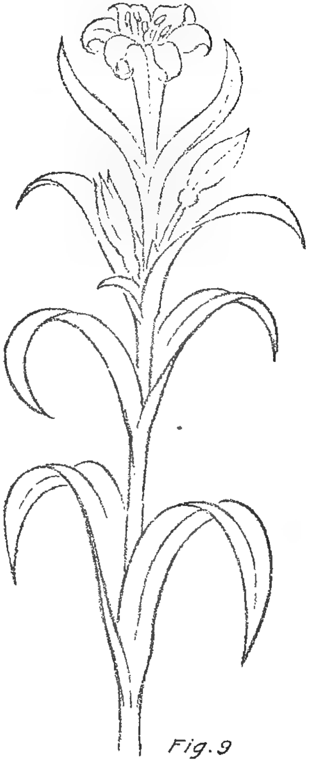

Fig. 9

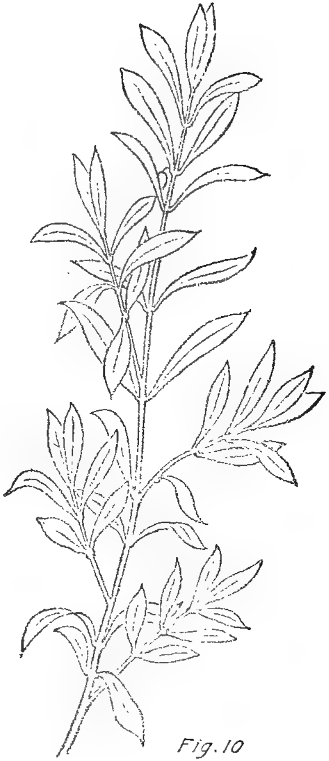

Fig. 10

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stems join them in a stiff, angular way at the lower indentation, and are heavy in proportion to the size of the leaf. The leaves do not show the wavy outline of the morning glory, for they are naturally stiff and somewhat clumsy. The stem from which the leaves branch is of a woody texture, and is much stiffer and harder than the stem of the morning glory; therefore, it does not grow in a wavy line, and care should be taken that, though the ivy is a vine and manifests as strong an inclination to climb as does the morning glory, it does so in a stiffer and more regular manner—a characteristic that should always be expressed when it is used in design. Draw Fig. 8 as shown, or from the natural leaves, if such are obtainable.

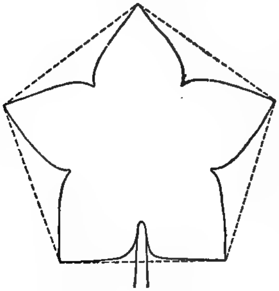

FIG. 25

Fig. 9 shows the long stem of the lily. There are several classes of lilies that manifest different characteristics in some of their details. This view shows the principle on which the leaves branch from the stiff stem, their tendency being to grow upwards toward the flowers, which bloom at the top. Each individual leaf is a plain straight blade, sometimes with a strongly marked central vein, and at other times with a number of veins running through it. Its lower end wraps itself partly around the stem, and in some classes, such as the tiger lily, the flowers blossom at the junction of the leaf and the stem, and after the flowers have blossomed a round seed marks the place where they stood on the stem.

Fig. 10 is a branch of the olive tree—a very difficult specimen to get from which to draw from nature, but an important leaf in design, as it has always been held as the emblem of peace. The leaf of the olive is long and narrow, very slightly widened at its upper end, somewhat after the general shape of the chestnut, but softer and not so conspicuously unequal. The fruit grows on branches under the

Exercise III *Title* *Sheet IV*

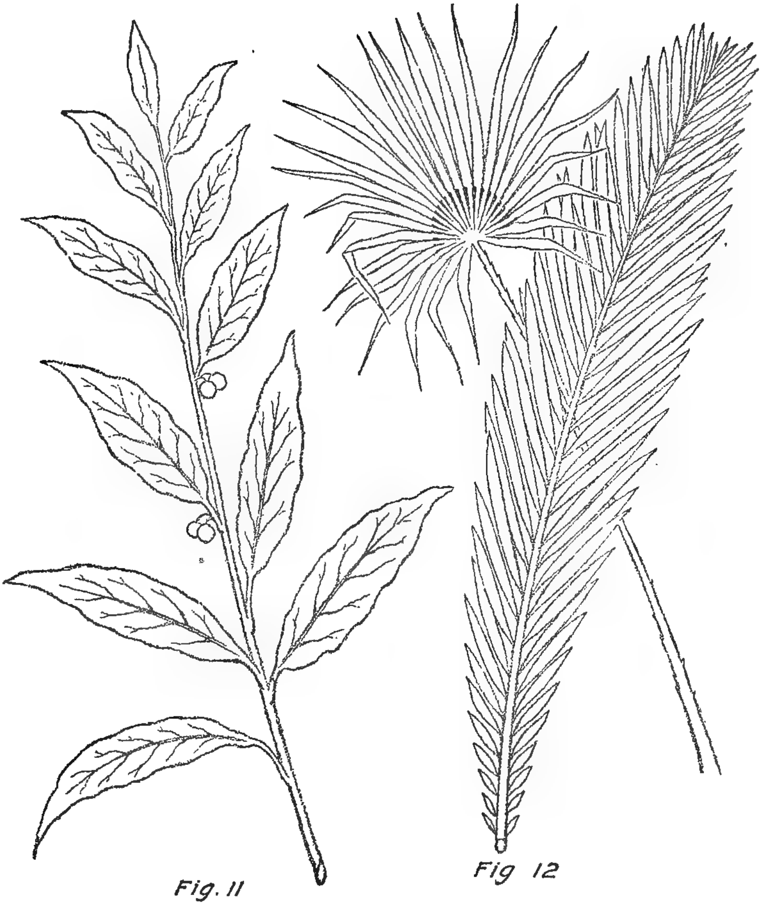

Fig. 11

Fig 12

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leaves, with six or eight olives on each branch. In drawing this little spray, it is necessary first to indicate the main stem about as shown in the exercise, and draw the two leaves that terminate at its upper end. The next two leaves below these grow out of opposite sides of the main stem, from the same point in height. They are not directly over the ones below or under the ones above, but take a position half way around the stem from these, so that if the stem were so held that any two of its leaves pointed toward the north and the south, the pair next above and below them would point toward the east and west. This is a characteristic that should always be borne in mind in representing the plant.

45. Exercise III, Sheet IV, contains Figs. 11 and 12. Fig. 11 is a branch of laurel introduced here with the olive on account of its symbolism, the laurel wreath being an emblem of victory. The shape of the laurel leaf is not widely different from the olive, but it is much larger, being 3 inches or more in length, while the olive is seldom more than 1½ inches or 2 inches. The leaves of the laurel grow all around the stem, branching alternately from opposite sides, and the edges, though not serrated like the rose leaf, are indented by a series of rounded notches at the end of each vein. The flowers of the laurel blossom in the angle between the leaf and the stem.

Fig. 12 shows two kinds of the palm—a plant emblematic of royalty. The palm leaf is used largely by the Egyptians in many of their designs, and from it were made several devices and utensils important in the ceremonies and customs of the complicated formalities of the ancient Egyptian society. In drawing the palm, observe that in one example the leaf radiates from the end of the stem, and bear in mind that though the edge is ragged and broken into a number of string-like terminations, its natural unbroken form is practically circular, and that the delicacy of the tissue composing the leaves causes them to be shredded on the edges when blown together in high winds or handled roughly when taken from the tree. This variety is known as the *fan palm.* The other form of palm, called the *feather palm,* is similar in texture of leaf to the first, but its veins radiate from a line instead of from a point. The border line and lettering on this sheet are placed as before, and all the sheets of this Exercise III, NATURAL LEAVES, then sent to the Schools for correction.

It is desired that the student should become accustomed to drawing rapidly and readily with the pencil and expressing himself with as few lines as possible. He must bear in mind that he is not to be a copyist, that no two leaves in nature are alike, and, therefore, it is unnecessary that he should portray any of the leaves in this exercise exactly like the example. However, he must remember that in each case he is solving a problem; he is endeavoring to express by means of a picture the idea of a certain form of leaf, and that failure to express all the characteristics of that particular leaf makes the solution of this problem incorrect.

EXERCISE IV, TITLE: FLOWERS AND CONVENTIONALIZED LEAVES

46. In Exercise IV, consisting of four sheets and including, in all, nine figures, there are given a few examples of familiar flowers, and the same remarks concerning the method of drawing and finishing them apply here as in the previous exercise. Original flowers are to be preferred to those shown on the printed copies, and whenever such are obtainable the student should avail himself of the opportunity to draw them. When such original studies are sent in, they should be supplementary to the regular exercise. Send regular exercise figures whether or not you send original floral studies.

47. **Exercise IV, Sheet I,** includes Figs. 1, 2, and 3, which should be neatly arranged across the 8″ dimension of the sheet, each one occupying one-third of the space.

In Fig. 1 is shown the morning glory, its bud, and the method of its branching from the vine. The flower itself is

Exercise IV

Title

Sheet I

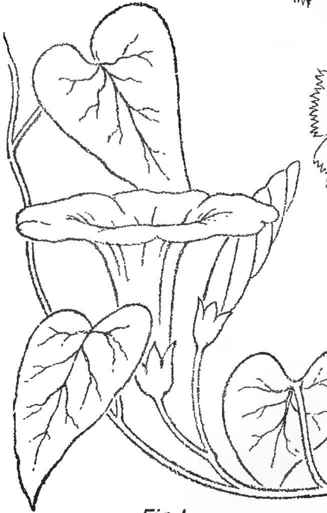

Fig. 1

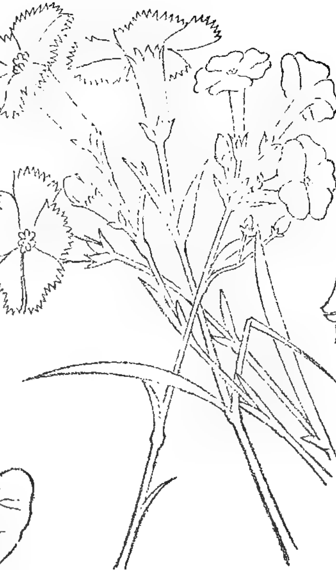

Fig. 2

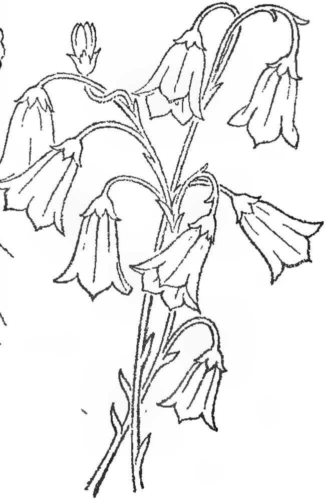

Fig. 3

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trumpet-shaped, the upper end being practically circular, which makes it elliptic when shown in perspective, as it is here. The sides of the tube forming the lower part of the flower are curved slightly, and gradually approach a straight line toward the stem. Observe that where they join, the little leaves around the bottom of the tube have pointed ends and form a cup called the *calyx*, in which the trumpet-like flower sets. Observe that the bud of the flower is twisted, producing a screw-like effect, as shown to the right of the open blossom.

Within this ellipse, describe the slightly scalloped edge of the upper portion of the blossom. For the top of the blossom draw an ellipse about $2\frac{3}{4}'' \times \frac{5}{8}''$. Draw the lines forming the trumpet-like tube of the lower portion of the blossom 2″ deep, and then draw the stem. The main stem of the vine runs from the lower right-hand to the upper left-hand corner, and by noting where it crosses the upper edge of the blossom, its position on the plate can be determined with sufficient accuracy. The leaves and the bud may then be drawn in their relative positions.

If the flower is drawn from nature, as heretofore suggested, these directions need not be closely followed, except so far as they apply to inserting each problem in its proper rectangle.

Fig. 2 shows two flowers somewhat alike in their general formation, but possessing characteristics that stamp them so forcibly that it is impossible to mistake one for the other; these are the phlox and the carnation. Both flowers possess five petals radiating from the center. The petals are larger at their outer ends and taper almost to a point where they come together. They enter the top of an almost straight tube that is held at the bottom by the little green calyx, where it joins them to the stem. This tube, however, is larger in the carnation than in the phlox, and the carnation itself is a larger flower than the phlox. The edges of the petals of the carnation are toothed very sharply and very plainly, while the edges of the phlox are round. The outlines of the ends of the flowers are practically governed by a pentagon, and in drawing them be careful to emphasize the characteristics of each, the strongest distinctive characteristics being the round petal of the phlox and the toothed petal of the carnation.

The outline governing the ends of these blossoms is practically elliptic, although the edges of the petals vary more in the carnation than they did in the morning glory.

In drawing the phlox, observe that the petals of the flower form a part of the tube that connects the flower with the stem, thus differing from the carnation, where the petals grow out of the tube. The outlining of the petals is practically the same, though on a smaller scale, and the governing outline of the top of the flower is an ellipse, as in the previous cases. Observe that the blossoms of the phlox are all on one stem, while with the carnation each separate stem carries a flower. The exact arrangement of these flowers in the exercise is not of importance as long as they are all within the border.

In Fig. 3 is shown a couple of sprays of a little flower known as the harebell. The flowers themselves are cup-shaped and hang from fine thread-like stems that grow alternately on opposite sides of the main stem. It has no large leaf like most flowers, but a series of little spur-like projections along the stem, as shown. The edges of the flower are indented by fine notches that curve in from the top, and the spaces between these indentations rise to little sharp points, giving the flower a very pretty and strongly characterized marking. The bud, as shown at the top of one of the sprays, is formed by the ends of the flowers closing over and folding themselves within, and does not twist around like the buds of the morning glory. In drawing the figure, try to keep the flowers in a graceful position; also, prevent any appearance of stiffness or forced regularity, and especially be careful to draw them with a light delicate touch, avoiding a crude hard line, as one of the strongest characteristics of this flower is its delicacy, and this would be destroyed by too harsh a rendering of the pencil. The border line and lettering should then be placed at the proper places.

Exercise IV

Title

Sheet II

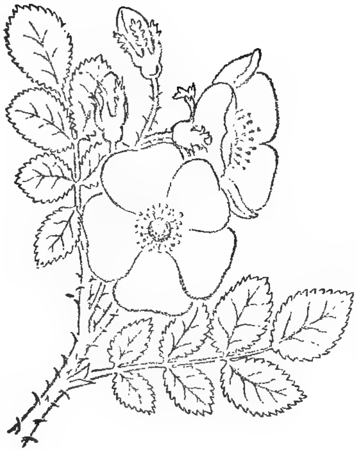

Fig. 4

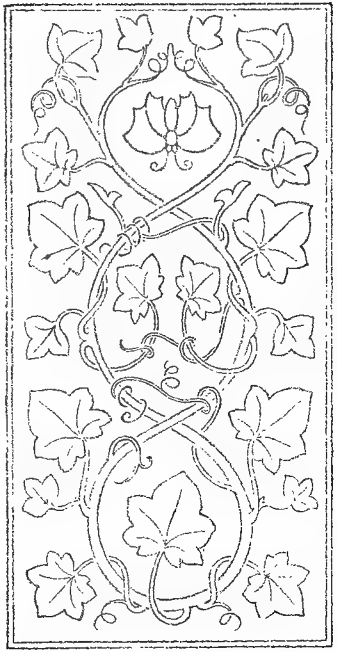

Fig. 6

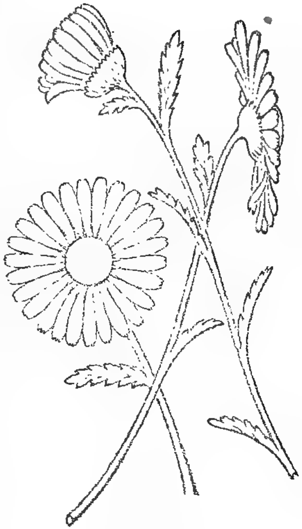

Fig. 5

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48. Exercise IV, Sheet II, includes Figs. 4, 5, and 6. Fig. 4 shows the ordinary dog-rose, the flower possessing five petals, which radiate from the center and are slightly curled up on their outer edges. Where they join, a series of fine hairlike filaments (botanically known as pistils) mark the center. The leaflets grow on opposite sides of a thin stem, usually three on each side and one on the end, and the edges of the leaves are sharply serrated, as explained on previous sheets. The thorn is characteristic of all kinds of roses, and should always be expressed as a characteristic of the plant.

Fig. 5 is the common field daisy—a flower easily obtainable during the month of June, and a very interesting subject for various classes of design. It grows at the end of a long stem, at the lower part of which the ragged leaves branch and spread on the ground. The flower itself varies in size from 1 inch to 1½ inches in diameter, is practically circular in outline, and consists of a number of white petals that branch from a central disk or sun in the center, about one-fourth the diameter of the whole flower. The petals vary in number, and branch out thickly on all sides, forming a solid white disk. The side view of the daisy shown in this exercise illustrates the tendency of the leaves to grow upwards slightly, and also shows the thickness of the sun or center piece below the petals of the flower. In drawing the daisy, it is well to sketch in the outline as a circle, and to draw the sun as a circle, and then, one at a time, indicate the petals or rays that branch around the edge. The petals are rather wider at their outer end than in the middle, and taper almost to a point where they sprout from the flower; two deep notches in the end cause three teeth to be characteristic of their outer extremities.

49. Plant Analysis.—Besides drawing the examples of wild flowers given in this exercise, every opportunity to study the flowers themselves should be taken; and after the details of each flower are drawn as seen in the blossom, the flower should be taken apart and analyzed. For example, pull apart a wild rose and make an individual drawing of one of the petals, or all of them, as shown in Fig. 26 of the text. Then study and draw every detail of every part of the plant so as to become familiar with the characteristics of the plant as separate from the plant itself. The leaves in their arrangement on the stem should be made the subject of another drawing, and this drawing of the details of the flower preserved as a guide to be used when the flower itself is expressed in a conventionalized design. The practice of thus drawing the details of a flower, or other vegetable form, is called **plant analysis**, and is the only way by which the strongest characteristics of every individual plant can be properly studied.

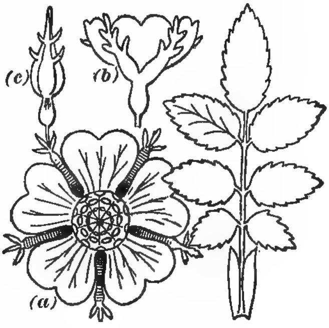

Fig. 26

In drawing the foregoing figures, always outline the grouping first, as explained heretofore. Then draw the individual outline governing the extremities of the flowers, etc., and finally fill in and develop the detail.

50. In Fig. 6 is shown a panel in which is drawn a conventionalized design based on the growth of the ivy, and which is, with slight alterations, a suitable design for carved wood or burnt-leather work, or even for embroidery. The details are not so conventionally rendered as would be necessary for certain woven work, such as damask linen, or silk, but the two sides of the design are precisely alike, and the details all geometrically arranged so as to reduce the whole to a mathematical principle. In drawing the panel, make its dimensions $3\frac{1}{2}''$ wide by $6\frac{3}{4}''$ high, and divide it into eight equal rectangles, as shown in Fig. 27 of the text. Within these rectangles, draw a number of pentagons, more or less irregular, according to the outlines of the various leaves, and generally indicate the lines of the main stem of the vine where it crosses the dividing lines of the squares. Notice that the center of the main stem crosses the center line of the panel *a b* about one-fourth of a square above the bottom, and it curves so as to cross the horizontal line *c d* a little less than one-half a square each side of the center line. The two stems then cross each other on the center line one-third of a square above the horizontal line *c d*, and they cross the horizontal line *e f* about one-half a square to the right and left of the center line. These stems then cross the line *g h* about one-third of a square each side of the center line *a b*, and cross each other on the line *a b* one-fourth of a square below the horizontal line *g h*. These measurements are not absolute and should be judged entirely by the eye. A principle to be observed is that the arrangement of the panel is based on the same rules concerning foliated ornament that were given in connection with Exercise I, title: Linear Elements. The strongest growth should be at the bottom, the arrangement of the leaves and area covered by them should diminish toward the top, and, though it is not the nature of the ivy that its leaves should grow tangentially from the stem, the stems should be so arranged that they appear to grow gracefully and rationally, one out of the other, without abruptness or severity. The main stem, however, should be stiff, rigid, and geometrical, as explained in the instructions for drawing the ivy leaf in a previous exercise, as this stem is stiff and woody in its natural growth. Within the pentagons that have been drawn to indicate the locations of the leaves, carefully outline the five lobes of the ivy leaf and connect them with a gracefully curved stem with the

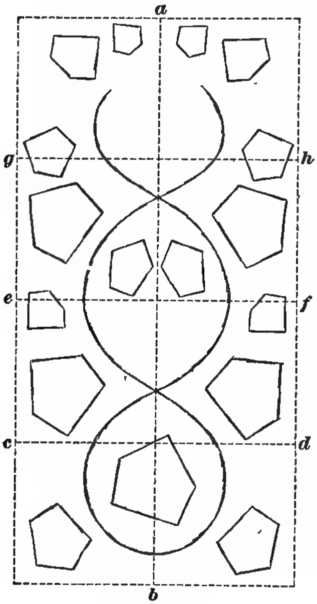

FIG. 27

main lines of the growth. Enclose the whole design in a border line, as shown.

51. In using such a design as this for practical work, the relative sizes of the stems and tendrils may be materially altered. Certain materials and methods of handling permit a much more delicate treatment than is here shown, while other conditions demand that all the lines be bolder and that some of the details at the top of the panel be suppressed entirely. For instance, if the design were to be embroidered, the colors to be used would determine largely the strength of the line of the stem, dark colors always looking heavier than light ones. The curve and arrangement of the fine tendrils at the top would also be altered, as the tracing of these lines would be governed by the possibilities of the handling of the thread employed. If the design were to be carved in wood, the tendrils at the top would probably be omitted entirely, and heavier forms replace the smaller leaves. The nature of woodwork would not permit so delicate a treatment at the top, and as the omission of the tendrils would leave a blank space that would look unfinished, the leaves themselves should be enlarged to satisfy the feeling that the proper area at the top had been covered. In the smaller stems, throughout the body of the panel, the design would probably require strengthening, that it might be better expressed in wood, and their increase would require a general increase in the thickness of the main stem throughout, in order that the proportions of one to another might remain the same. After having carefully outlined these details, strengthen the general lines of the drawing, clean up the guide lines, and then finish the figure in pencil.

Place the border line and lettering at the accustomed places.

52. Exercise IV, Sheet III.—With Fig. 6 of this exercise we take up the first part of the subject of conventionalized forms. It is seldom that a plant or other form from nature can be used in a design with reason without reducing it to a plain practical form that is conventional or symbolic

Exercise IV

Title

Sheet III

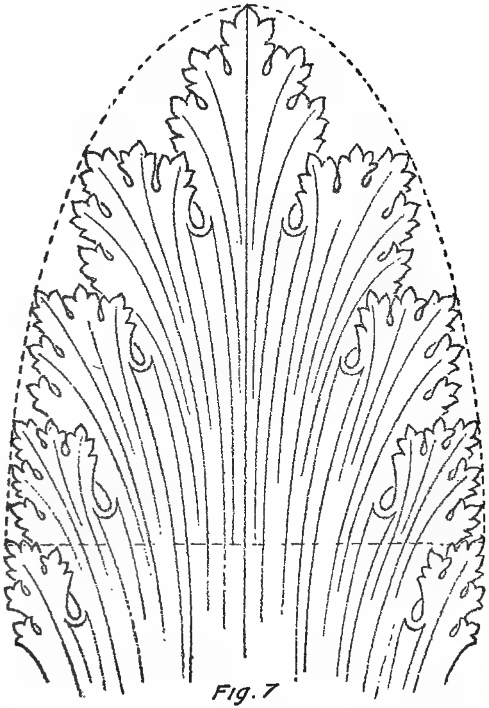

Fig. 7

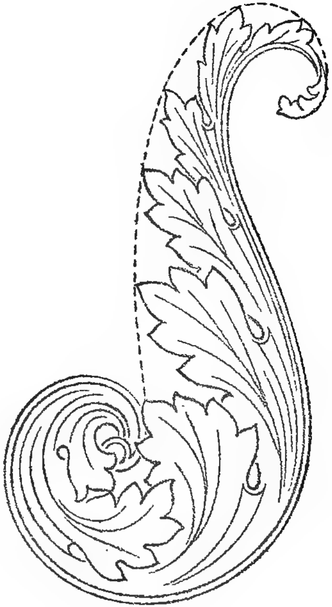

Fig. 8

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more than pictorial. Fig. 7 is a conventionalized form of the acanthus leaf, and as we draw it we will endeavor to get a better idea of the meaning of the word *conventional.* In the first place, the outline of this figure is based on the ellipse; therefore, construct a semiellipse $5\frac{3}{4}''$ high and $5''$ wide. Within this, draw the main outline of the lobes of the leaf, as shown in Fig. 28 of the text, observing that these lobes are farther apart as they approach the top of the leaf, or, in other words, are closer together at the wider portions of the leaf. There is a central lobe and three smaller ones on each side. The top lines of the side lobes are curved, but are nearly horizontal in position, and the side lines of the lobe are inclined slightly toward the center of the leaf. The middle vein is a straight line on the major axis of the ellipse, and the side veins curve from the points of the lobe to the bottom line, as shown, and approach the central vein as they reach the bottom; in other words, if all the veins of the leaf were continued downwards, they would eventually meet in a point like the lines radiating from a point in Fig. 18 of Exercise I, title: Linear Elements. The acanthus leaf is now drawn by serrating the edges of these lobes, following the exercise as closely as possible. The inner angles of the lobe are then carried into the leaf in the form of loops, the vertical lines usually being the ones that govern the direction of the loop. The leaf lobes are then drawn as though lapping over one another slightly, and extra lines are drawn indicating the sides of the pipes or tubes that are naturally formed in the leaf where these loops exist. It will be seen that the sides of the leaf on this exercise are symmetrical, that the leaf is perfectly flat

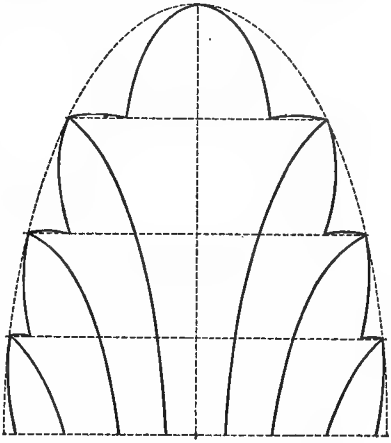

FIG. 28

in the drawing, and no attempt is made to shade it. The existence of the last line drawn from the loops down is indicative of the raised surface of the pipes on the leaf. This is the expression of an idea by means of a picture. It is not a picture of the acanthus leaf as it appears in nature, but a picture of the characteristics of the leaf—characteristics that are themselves emphasized beyond the mere drawing of the leaf itself, and it is the emphasis of these characteristics that distinguish in the drawing of a leaf or flower the naturalistic and the conventional rendering. Flowers and leaves may be rendered naturalistically if they are painted on canvas or printed on paper, but if woven in cloth or carpet, or used as a part of a wallpaper design, or burned in leather, the details of the process by which they are thus reproduced will not permit of an accurate portrayal of them naturalistically. They are therefore conventionalized, and lines indicating their strongest characteristics are woven, printed, or carved to stamp the leaf for what it is.

Fig. 8, Sheet III, is a side view of the conventionalized acanthus as it is sometimes used in connection with scrollwork on brackets. The **S**-like outline of the leaf is first drawn about 6½″ high; the lower curve is then drawn to measure 3¼″ across; and the upper curve about 1½″ across to the dotted guide line. The lobes are then outlined exactly in the same manner as the previous case, and the indentations drawn within these outlines, as before. The veins running from the center of the lobes are then drawn, following the contour of the lobe itself, and finally becoming tangent to the main curve at the outside of the leaf. After the leaf has been drawn, the guide lines, which are shown dotted in the exercise, may be erased and the drawing of the leaf itself completed.

The border line and lettering are then to be located as before.

53. Sheet IV.—Fig. 9 is a bracket and hanging sign, similar in every respect concerning its general outline to the bracket and sign in Exercise II, Sheet II. Draw the outline of this bracket and sign precisely as before, but where the

Exercise IV

Title

Sheet IV

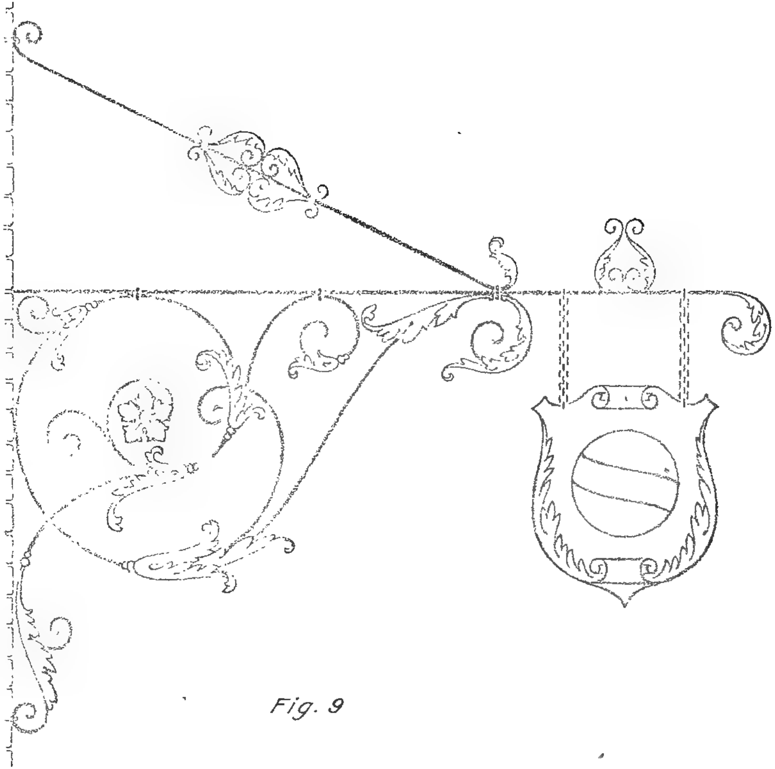

Fig. 9

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lines of ironwork split and branch into separate scrolls, cover the joint with drawing of a conventionalized leaf, the details of which have just been studied. The length, size, and proportions of the different parts of the leaf must be judged by the eye, observing that the outline of the leaf follows closely the outline of the ironwork that it covers, and observing, also, that a plain strap-iron bracket is being converted into an ornamental device, requiring in its execution the greatest skill in the ironworkers' art. It is also well to know that in the execution of a design of this character for an ironwork bracket that might be used either as a sign hanger or as a design for a chandelier or gas bracket

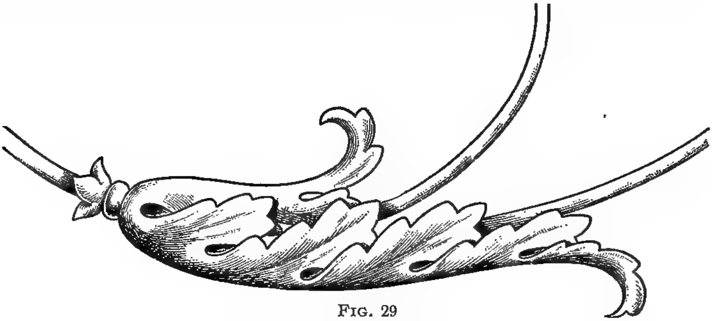

Fig. 29

it is necessary to exercise the same judgment in the formation of the leaf as was necessary when drawing the cartouch. The leaf must be cut out of plain sheet iron by the ironworker, and hammered into the shape expressed by the designer on his drawing. It is well, then, for the student to study what the developed shape of this leaf would be if it were flattened out. He will probably then find by experiment that the leaf can be improved in design by varying some of its dimensions. Fig. 29 shows a piece of iron scroll projecting from a hammered ornamental iron leaf, while in Fig. 30 a developed form of the larger part (the lower) of this leaf is shown in outline before it is hammered into this shape. It is a simple matter, and a very instructive practice, for the student to experiment in drawing and making these devices of paper or thin metal, as was suggested in the drawing of the cartouch. Very thin brass or copper is an excellent material to practice with. It may be readily cut to any desired shape with ordinary scissors, and bent and creased with the fingers to bring it up to the finished shape, and the student that can both draw and model his designs will be in better shape to execute satisfactory compositions than the one that is simply satisfied to express his ideas on paper. The border line and lettering should be placed at their usual places. To save time and trouble the title may be lettered as FLOWERS AND LEAVES. All the sheets should then be mailed flat, as before, to the Schools for correction.

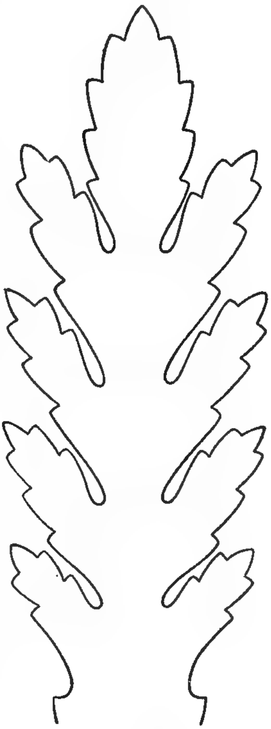

FIG. 30

OUTLINE ORNAMENT

54. In **outline ornament,** a figure is expressed by a series of lines that contour its principal parts. If the object be a rosette, as in Exercise V, Sheet I, the entire figure is expressed by a suitable outline, and the details of its surface expressed by other lines limiting their boundaries. It is impossible in this method of drawing to express rotundity or curvature of surface, and this is not intended, but where any portion of an ornament comes into sharp relief so that it is likely to cast a clean line shadow, then a clean line may be used to profile it. In design work in general, ornaments are worked up in this character, and a few of them are afterwards treated to express in detail the character of the whole. The drawing is thus simplified and the character of the design shows up to much better advantage than if every element of the ornamental surface was carefully finished.

Take, for instance, the introduction of any one of these figures in an Arabesque design repeated at regular intervals over an entire wall surface. If all these repeated figures were worked up with the exactitude that rendered one a perfect duplication of the other, in color, light, and shade and outline, the effect would be monotonous and the eye would wander from one detail to another without resting and the scheme presented would not carry to the observer the same idea that it would if executed in this manner on the wall of a room. On the wall of a room the surface is so extended that the eye cannot take it in at a glance and therefore falls on an individual figure and unconsciously derives its impression of the whole room from the impression of the one detail. In rendering the drawing of any large surface treatment, it is therefore advisable to have only a few of the details worked up in a finished manner, so that the eye may appreciate these and receive of the others a general effect harmonious with the first.

Exercises V and VI will be in ornamental drawing, and the student may draw all construction lines for them with instruments, but the devices themselves are to be executed entirely freehand. A 3H pencil should be used for the construction lines, but a B or 2B should be used to finish the outlines and shaded portions of the ornament.

EXERCISE V, TITLE: OUTLINE ORNAMENT

55. To draw the figures in Exercise V none other than approximate directions will be given. It is intended that the student shall learn to discover for himself methods of proportioning the parts of a figure without receiving minute instructions for each line. The illustrations herewith shown are about one-half the size the student is to draw them, but no exact dimensions will be required as long as one part is properly proportioned to another.

56. Exercise V, Sheet I.—To draw the two rosettes on Sheet I, divide the sheet through the middle by a light

Exercise V Title Sheet I

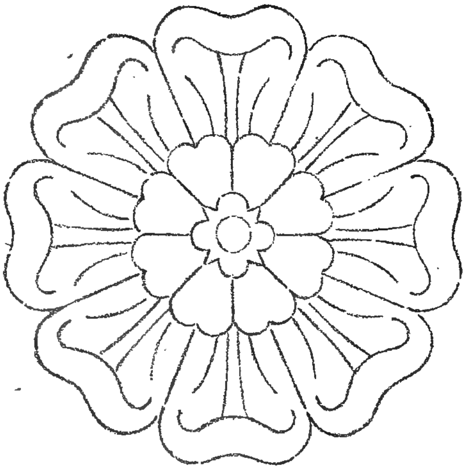

Fig. 1

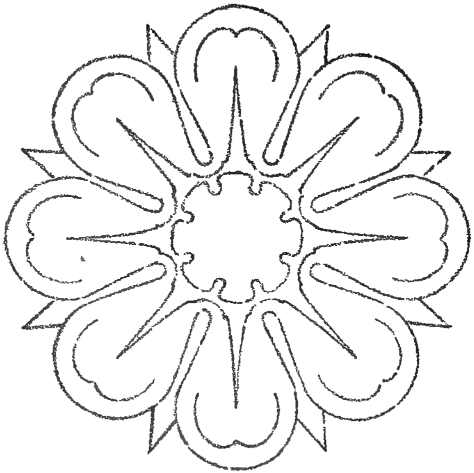

Fig. 2

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vertical line, thus establishing two panels, in the center of each of which locate one figure. The best way to draw Fig. 1 is to draw in the center of the panel a square whose sides are equal to the breadth and height of the rosette, and then to construct an octagon within this square, according to Problem 18 in *Geometrical Drawing.* As this rosette has eight sides, each side of the octagon will mark one side of one of the leaf forms that constitute the rosette. The diagonals of the octagon will make the lines separating these leaves. After locating these details, the rest of the figure can readily be drawn in. Be careful to proportion the inner rosette to the outer one, and observe that the center detail consists of two sets of forms each—that is to say, four semicircles separated by four acute angles.

After completing Fig. 1, clean up the drawing and erase as far as possible the main construction lines. Then cover over this half of the sheet with a piece of paper to protect it while Fig. 2 is being drawn. Study Fig. 2 carefully. It can also be drawn in an octagon but the octagon will not be in the same position as in the case of Fig. 1. Devise a method of proportioning the different parts, and then draw in the rosette. *Do not erase* the construction lines in Fig. 2, but leave them so that we can see the method used.

After completing the sheet, letter it at the top with the title OUTLINE ORNAMENT and the number of the exercise and the number of the sheet, and at the bottom with the date, time consumed on the work, your name, and class letter and number.

57. Exercise V, Sheet II.—To draw Sheet II divide the paper within the 8″ × 11″ border as before, and in each of the two panels thus formed draw a vertical center line that will make the center of the two conventional flower outlines. The floral top of Fig. 1 is the widest part of the figure, and a horizontal line, representing this extreme width, should be drawn about one-fourth the height of the figure below the top. From the ends of this horizontal, lines should be drawn to the lowest part of the figure, thus

Exercise V *Title* *Sheet II*

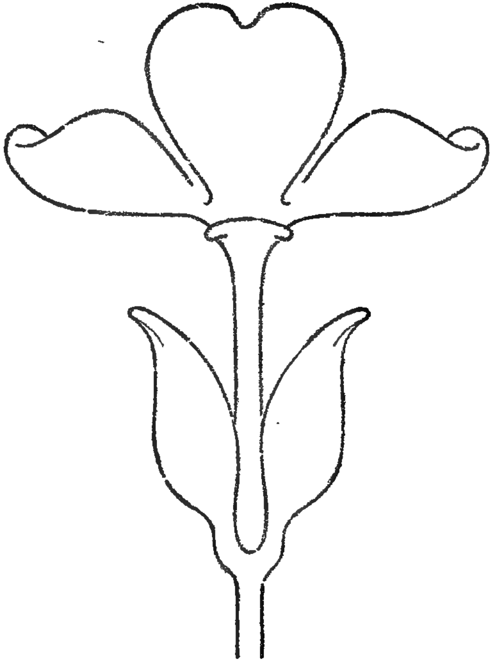

Fig. 1

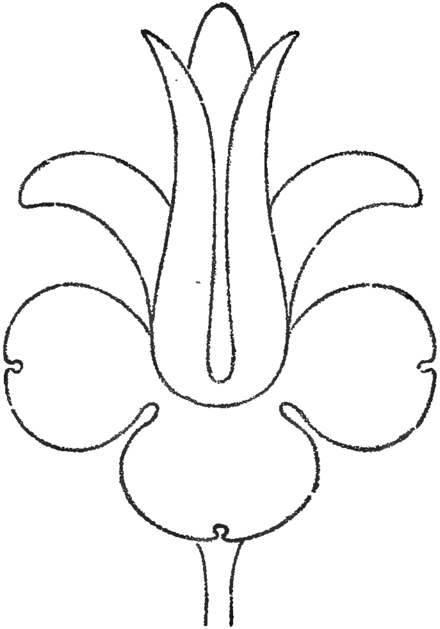

Fig. 2

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Time consumed in executing this sheet

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constructing an inverted isosceles triangle. The sides of this triangle will be tangent to the lower part of the leaf forms that branch from the stem below the flower. Having constructed these guide lines with instruments, carefully draw in the outlines of the device, and when finished cover it with a protecting sheet of paper and proceed with Fig. 2.

The governing outline of Fig. 2 is an oval with its small end upwards, or if an outline for the whole figure, including the short lower piece of stem, is wanted, it can be drawn in an ellipse. In either case, the width of the figure across the two upper radiating leaves is about two-thirds the height, and a line drawn across this width, a little less than one-third the height from the top, will form the base of an equilateral triangle whose apex is in the edge of the lowest leaf lobe. Figures of this character are frequently found in the Arabesque ornaments so characteristic of Renaissance panels. Draw this triangle and then carefully outline the figure. Letter the title OUTLINE ORNAMENT, exercise number and sheet number at the top, and the date, time consumed, the name, and class letter and number at the bottom, as usual.

58. Exercise V, Sheet III.—Fig. 1 of Sheet III is developed on a skeleton of radiating lines similar to Fig. 18 of Exercise I. The extreme width of the ornament is at a point about one-third up from the bottom, and this width is about two-thirds the total height. The width across the overhanging leaves at the top is about one-half the total height. A line connecting the end of the overhanging leaf at the top with the end of the calyx leaf at the bottom will form a guide line by which the other details may be located. Draw the above lines in pencil on the illustration here, and then duplicate them, increased in scale, on your drawing sheet.

Fig. 2 involves a combination of Figs. 16 and 18 of Exercise I. Draw a horizontal line through the right panel of the sheet about three-eighths the height from the bottom. On this line lay off the width of the figure across the volutes; then, with the marked width on one side, construct a square to contain the entire upper portion of the figure. The

Exercise V

Title

Sheet III

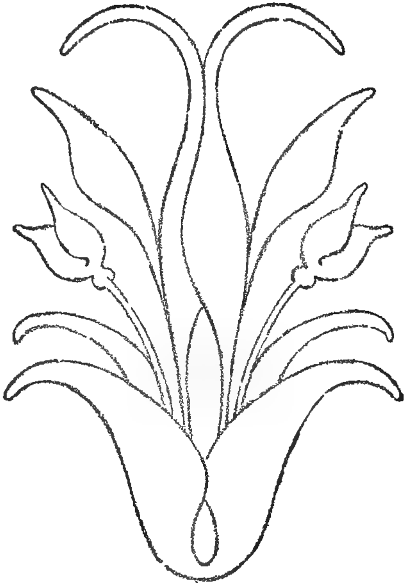

Fig. 1

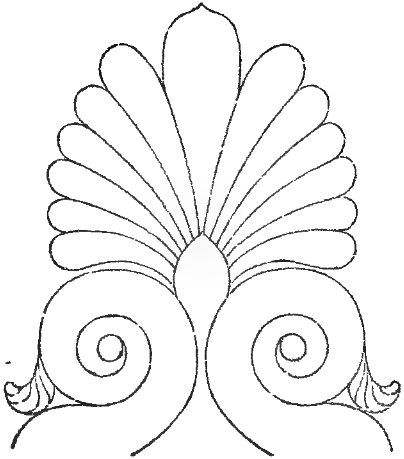

Fig. 2

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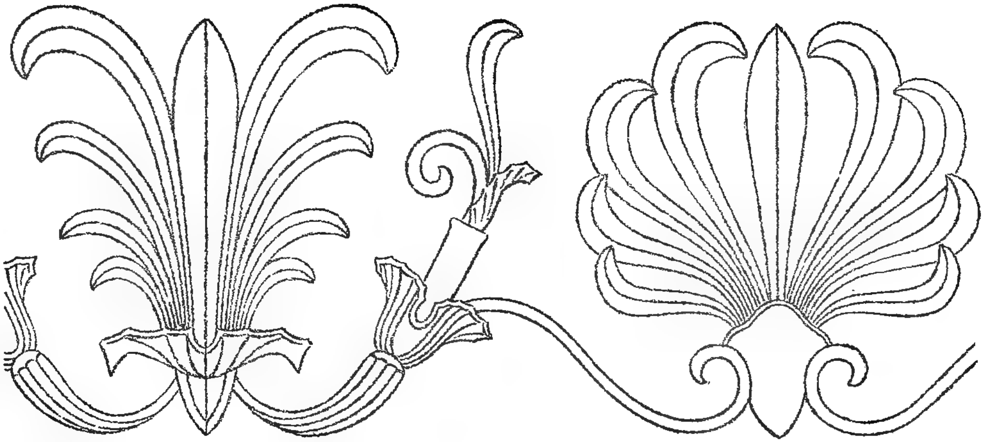
Exercise V *Title* *Sheet IV*



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Time consumed in executing this sheet

Name of Student, Class Letters and Number

general outline of the radiating palmette form is a semiellipse whose semimajor axis is equal to its minor axis. The minor axis, which is also a side of the square just drawn, passes through the eyes of the volute. Draw in the outlines of the leaf forms and the volutes, and complete the figure as shown. The proportions of the volutes can be judged by the eye, as it is unnecessary to lay out their curves mathematically, as in Fig. 16, Exercise I. Letter the title OUTLINE ORNAMENT, exercise number, sheet number, name, class letters and number, etc., in their usual places.

59. Exercise V, Sheet IV.—The figures on Sheet IV are part of the running honeysuckle ornament characteristic of Greek art. The governing outline of the left-hand figure is an inverted triangle, while that of the right-hand one is a circle. However, neither outline conforms exactly to these geometrical forms, as will be seen by applying the form to the illustration. The vertical center lines of the two figures should be drawn about 6″ apart, and two parallel horizontal lines 4½″ apart should be drawn to limit the height of the ornament. The triangle and circle that are to form the governing lines of the two figures should be drawn with instruments and the details of the form filled in freehand. Letter the sheet as the preceding ones.

SHADED ORNAMENT

60. Shaded ornament bears the same relation to outline ornament in black and white designs as colored ornament bears to shaded ornament in color design. The outline must appear in shaded ornament just as much as in outline ornament, but need not necessarily be expressed by a hard and wiry line. It is an old saying in drawing instruction that "nature abhors an outline," and many authorities state positively that such a thing as outline cannot exist. This is a hard fact to understand as we immediately picture the definite outline of a green tree against the sky, or of a painted house against a thick foliage. We feel that the house actually possesses an outline, and should be so expressed if rendered in a drawing or painting. It is the mechanical conception of this hard and fast line of the tree, as separate from its background, that prevents us from understanding the assertion that there is no outline in nature; but if we mentally picture a case where the tree, or the house, or any other object, no matter what, is of exactly the same value in light and shade and color as the background against which it was profiled, no line of demarkation between the two could be seen. Therefore, what we consider as the line between two such objects is simply the point where two shade values or two color values meet and one is thus seen contrasted to the other.

This should be borne in mind in making these drawings of shaded ornament. In each case, a delicate outline drawing should be made, and on that outline drawing the high lights, or those portions that are most brilliantly illuminated, should be carefully sketched. The line that marks them should be so light that it can be seen only as the work is being done, and should disappear almost entirely when the drawing is finished. The difference between one portion and another can then be expressed by bringing the shaded portion of the drawing up to the light portion and letting the limited shadow mark the line between the parts. Take, for instance, the simple leaf form in Fig. 1 of Sheet I. The entire right side of the form is in shade except the upper edge of the lower leaf lobe. The line separating the light portion on the left from the shaded portion on the right should not be considered as the outline, but simply as the meeting of two planes, one darker than the other. This line disappears almost entirely as we approach the top of the center lobe where two shaded portions come together. But the mind is so subtle and can so easily grasp what is intended by the merest suggestion, that it carries this apparent dividing line clearly to the point of the leaf, although no effort is made to preserve its identity there at all. This ornament is in low relief against the flat background. The leaf is expressed by the lines drawn beyond the shaded portions of all the leaves to express a thickness of material between the shaded lobe and the background *m* here, even in shaded ornament, an outline is necessary because the high light of the background and the high light on the ornament itself must be distinguished. If this drawing were rendered in color, this distinction might be effected by a difference of hue. On the center lobe, the relief of the background is distinguished by a shadow cast in a deeper tone than the shade of the lobe itself.

In shaded drawings, a distinction should be made between the shade and the shadow. The **shade** is that portion of the surface that does not receive as much light as some other portion, and varies in depth of tone according to the extent it is turned away from the light. The **shadow**, on the other hand, is that portion that is excluded from light almost entirely, owing to the presence of something in relief between it and the source of light. The shadow is always deeper in tone than the shade. In a cylinder, cone, sphere, or other curved surface, there is one spot that receives the full possible percentage of light; this is called the **high light**, and as the surface curves away from this high light it receives less and less illumination until the point is reached where there is none at all, and generally speaking is as dark as the cast shadow.

In rendering these drawings in shaded ornament, bear in mind that outlines are used only where they are necessary to separate two high-lighted portions from each other, and that in every case possible the line marking the boundary between two general surfaces should be expressed by shading one surface up to the point where it comes in contact with the other.

EXERCISE VI, TITLE: SHADED ORNAMENT

Exercise VI consists of four sheets, the execution of which gives practice in indicating the effect of light and shade on the surface variations of ornamental forms.

61. Exercise VI, Sheet I.—The conventional leaf form shown in Fig. 1 consists of three lobes, the two smaller ones

Exercise VI *Title* *Sheet 1*

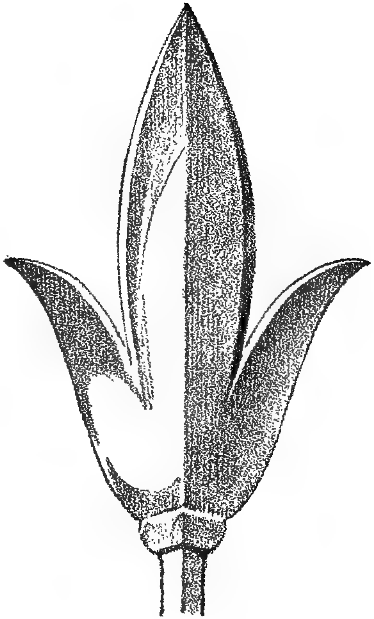

Fig. 1

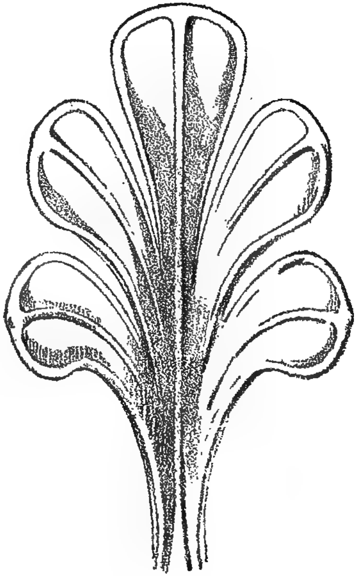

Fig. 2

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spreading in width to about two-thirds the entire height of the figure. Draw this form carefully in outline and then with a very light pencil line indicate the outline of the high lights on the left side. Draw a light vertical line through the center and then carefully shade the right side with a 2B pencil. The shading is composed of a series of even, parallel strokes sufficiently close together to form an even tint, but which on close examination exhibit their individuality as pencil lines. There is a slight variation in the depth of these lines, which can be observed by closing the eyes partially and viewing the figure through the eyelashes. The shadow to the right of the main lobe is somewhat deeper than the shade on the leaf itself and thereby throws the figure in relief. There is but slight difference between the center of the lobe and the edge, but at the same time there is a difference, and the lighter shade is at the right edge. The shade on the two smaller lobes deepens toward the top where the stripe of high light indicates that the edge is beveled.

Fig. 2 may be conveniently outlined within an ellipse whose minor axis is about two-thirds its major axis. Radiating lines should be drawn from the bottom of the ellipse locating the center ribs of the leaf lobes, and the outlines of the lobes then drawn. The vertical central rib extends to the top of the center lobe without diminution in width or projection; there it unites with a raised rim of the same size that follows the outlines of the lobes. This rim and the lateral ribs, however, diminish in width and projection as they approach the center of the leaf, where they die out entirely.

In shading this leaf, the lower and right-hand edges of the lobes and ribs should be emphasized slightly with a soft pencil and the curvature of the surface indicated as shown by a flat gray tint similar to that in Fig. 1. Letter this sheet in the same manner as the sheets in the previous exercises.

62. Exercise VI, Sheet II.—The three figures on Sheet II are shaded more after the manner that is to be recommended for conventional work. On Sheet I, the pencil lines were so close together that they appeared as an

Exercise VI Title Sheet II

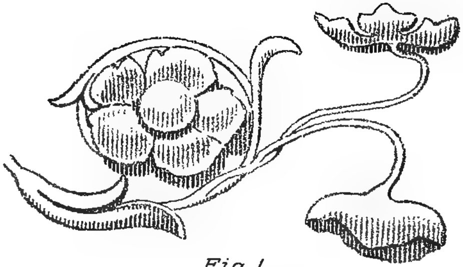

Fig. 1

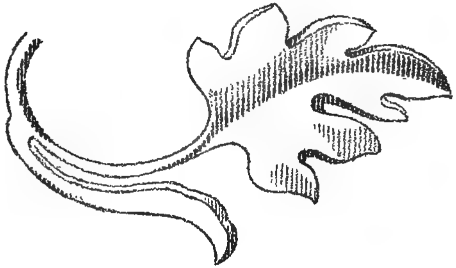

Fig. 2

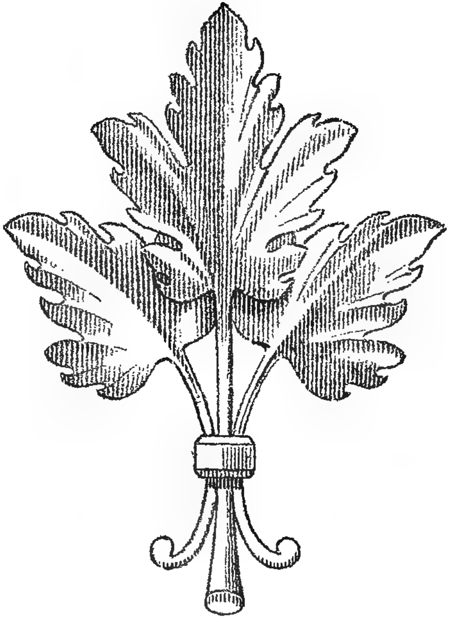

Fig. 3

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and Number

even flat tint; on this sheet and those that follow, the shade lines should be separated sufficiently to show their individuality, and to vary their color by increase of pressure on the pencil in rendering them. The outlines of Figs. 1 and 2 are too simple to require description. The leaf part of Fig. 3 can be constructed within a square standing with one end of a diagonal at the vertex of the center leaf and the other end of the diagonal in the center of the ring or band uniting the stems of the three leaves.

The shading of Fig. 1 consists of simple short strokes even in tone and uniform in spacing, so placed as to show the shade on lower curved portions of the ornament. The shadows cast against the background should be made with a heavier stroke and a thin white line should be left between the cast shadow and the surface shade of the ornament. In shading Fig. 2, observe that the indentation at the central vein is expressed entirely by the shading, while a portion of the lower outline is expressed entirely by the shadow. Close the eyes partially and observe through your lashes the grading of each line in the rendering in order to deepen the shade toward the central vein. The shading on Fig. 3 is even in tone without deepening toward the vein, as in Fig. 2, but the lower and right edges are emphasized here and there to add character to the outline. Place the usual lettering on the sheet.

63. Exercise VI, Sheet III.—Draw Fig. 1 in a circle 5″ in diameter, and Fig. 2 in a triangle 4″ wide and 6½″ high. The leaf forms of Fig. 1 should first be drawn in general outline, the five being arranged similar to the lobes in Fig. 2 of Sheet III, Exercise V, except that there will be but two lobes each side of the center in this case instead of six as in the previous case. Finish Fig. 1 of this sheet in outline and then carefully shade in the background, varying the weight and strength of the lines as shown. Short light strokes on the lobes of the leaves indicate their rotundity, and the emphasis of the outline throws the whole into relief.

In drawing the outline of Fig. 2, which is the crest of a

Exercise VI *Title* *Sheet III*

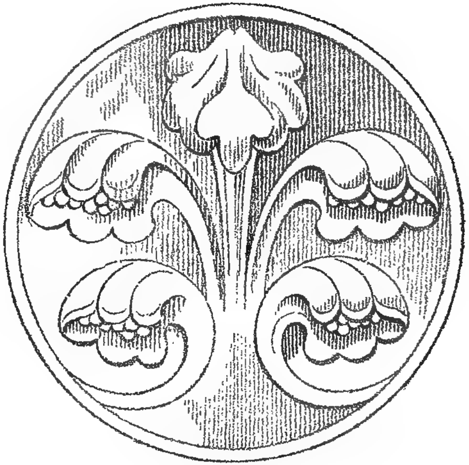

Fig. 1

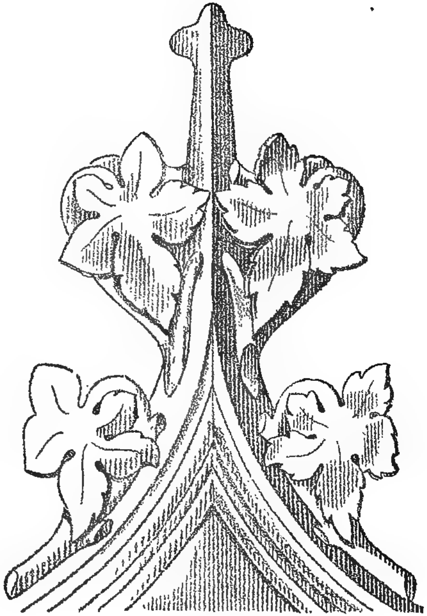

Fig. 2

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Gothic gable, the vertical center line forms the rib of the pinnacle, which splits about half way up and curves out to the lower angles of the enclosing triangle with a radius of 4″. The indicated moldings below this are parallel to this split rib, as shown. The sides of the enclosing triangle pass approximately through the centers of the carved leaves, which centers are about 2½″ from the apex of the triangle and 1½″ apart. Just enough shading is introduced into this drawing to indicate the curved form of the surface of the leaves and moldings and emphasize the shadow side of the pinnacle and its sweep to the right-hand corner. Letter this sheet in the same manner as the preceding ones.

64. Exercise VI, Sheet IV.—Fig. 1 of Sheet IV is drawn in a triangle whose base is 5″ wide, and whose altitude is 6½″. The rib that marks the center line of the pinnacle splits just below the center of the height and branches into the corner of the triangle, as in Sheet III, at a radius of about 4″. Of the foliated ornaments, the upper two are attached to the pinnacle itself, and the lower two are on the upper slopes of the gable. The upper ones spring from the pinnacle about 2″ from the top, and the lower ones from the curved gable lines a little more than half way up the slope. These should be sketched in outline so that the extreme width across the upper pair is about 3″, the lower ones being made in proportion. Their outlines should be very delicately rendered with a hard pencil so that the line is scarcely discernible, depending on the contrast between the light and shade values to determine the outline. The center line of the pinnacle and its outline, except at the top, had better be drawn mechanically, and also the curve where it splits and sweeps into the corners of the triangle. The other curves can be drawn lightly with the compass, if desired, but should be rendered freehand with a soft pencil afterwards in order to destroy the mechanical effect. The shading should be commenced with the pinnacle itself and carried out with a soft pencil, frequently sharpened, in order to preserve the individuality of line. Where the leaves of the foliated ornament

Exercise V.

Title

Sheet IV

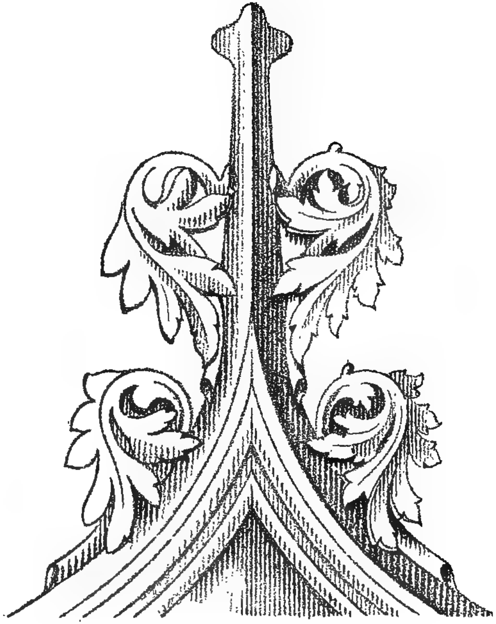

Fig. 1

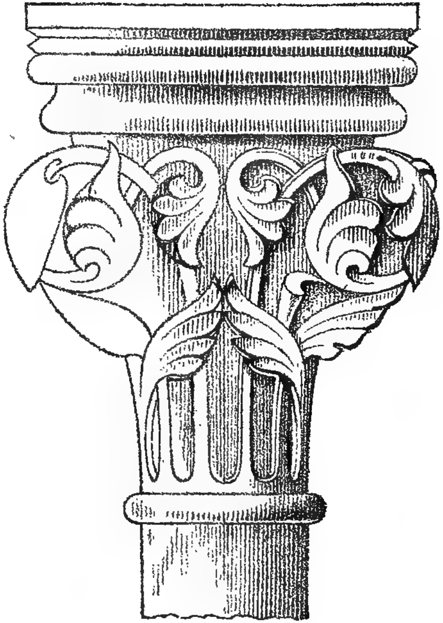

Fig. 2

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extend over on to the shaft of the pinnacle, care should be exercised to preserve their outline simply by contrast. The left side of the pinnacle is shaded but slightly, in order to distinguish its outline against the white background, and the foliated ornament on the left side is drawn in outline only, whereas on the right side it is both outlined and shaded. The portions that are deeply cut should be emphasized in shading, in order to get the effect of a strong shadow. Observe that while the ornament on the left side of the pinnacle is drawn in outline only, that on the right side introduces more detail. The leaves end in three points instead of one, and the method of rendering partakes of the same character as did the acanthus leaf in Exercise IV.

Fig. 2 is a Norman capital. Its abacus or upper slab is about $4\frac{1}{4}''$ wide, and a little less than $1\frac{1}{2}''$ deep to the bottom of the moldings. The bottom of the necking where it joins the shaft is $5\frac{1}{2}''$ below the top of the abacus, and this necking is about $\frac{3}{8}''$ wide. The width of the shaft below the necking and at the capital above it is $1\frac{3}{4}''$, but it spreads out in a slight curve about $3\frac{1}{4}''$ where it supports the first molding of the abacus. The width of the capital across the foliated ornament is considerably wider than the top of the abacus, being about $4\frac{5}{8}''$. Observe the stems of these leaves as they grow up over this bell-shaped top, making a series of ribs, over which some of the lower leaves lap. Draw these veins in lightly at first, arrange the overlapping leaves over them about the middle of the capital, and also similar leaves that sweep to the right and left and support the broadest part of the projecting ornament. Detail all of this carefully in outline, and then proceed with the shading.

The first shading on the abacus consists of the beveled edge of the upper member. An angular fillet is presented next with its two surfaces expressed with the shade lines only. The round member, called a bolus in this style of architecture, is shaded on its lower half only in order to express the curvature, care being exercised to leave a white thread-like line between that and the shading of the hollow member beneath. The hollow member is then shaded at the top and with more pressure on the line at the top than at the bottom in order to grade the tone. This can be observed by looking at the illustration with partially closed eyes. Shade the bell of the capital in a simple even tone next; this will throw the details of the ornament into relief, and very little shading on the ornament itself will suffice to give it character. The left half of this figure remains entirely in outline in the illustration, the purpose of this being to give the student a clearer idea of the structural character of the ornament. The leaves are blocked out rather than finished in detail so that he may see what general forms to sketch in first. When the drawing is completed, however, the shading should be carried over the entire capital so as to present it as a finished whole. Letter this sheet, in the same manner as the preceding ones, with the title SHADED ORNAMENT, exercise number, sheet number, date, class letters and number, etc., and send all the sheets of the exercise to the Schools for correction.

65. These four sheets represent various forms of detail that are met with in every branch of applied design. They are all, more or less, architectural in character, but as conventionalized forms they represent a class of ornament that pervades all branches of art. Where they are included in stone, plaster, carved wood, or other relief work, they present details that must be shaded in a drawing to express them. Where executed on the flat, as for wall decoration or textile work, their variation of surface may be expressed in light and shade or color. For work of this character, shading should be applied in the most conventional manner, the intention being simply to indicate details by a few masses of high light and shadow without attempting to give a pictorial rendering such as would be required in a book illustration, or a drawing for pictorial purposes. This conventional method of rendering brings out the characteristic details of the ornament, which are important in this first work.

Where the ornament is subordinate to something else, as it would be as part of an illustration, or a detail of an architectural design, it can be expressed with fewer lines and less attention need be given to the proportioning of individual details, as it would then blend with the whole composition and give a more satisfactory effect.

WASH WORK AND BRUSH DRAWING

EXERCISES

1. In architectural drawing, color or wash work is used in various ways to represent texture or material. The term **wash work** is used because the color is laid over the drawings in thin transparent washes that permit the pencil or ink work to show through, when desirable, after the color is laid. These washes are divided into two general classes; namely, *flat washes* and *graded washes*. **Flat washes** are used to show sectional parts of plans or details and to indicate at the same time the material through which each section is taken. Thus, we color in the wooden, stone, and brickwork walls of our plans to show their material. **Graded washes** are used to render finished drawings pictorial. They are rarely used to show sections through materials, but are applied to elevations and accessories to express material and give warmth and texture to the composition.

2. This Section will consist of four exercises executed on 9″ × 12″ sheets with an 8″ × 11″ border line. The purpose of these exercises is to train the student in handling the brush so as to lay both flat and graded washes as will be required in subsequent architectural problems. The paper on which these drawings are to be executed should be either Whatman's cold-pressed, Strathmore, or "TEC" water-color special.

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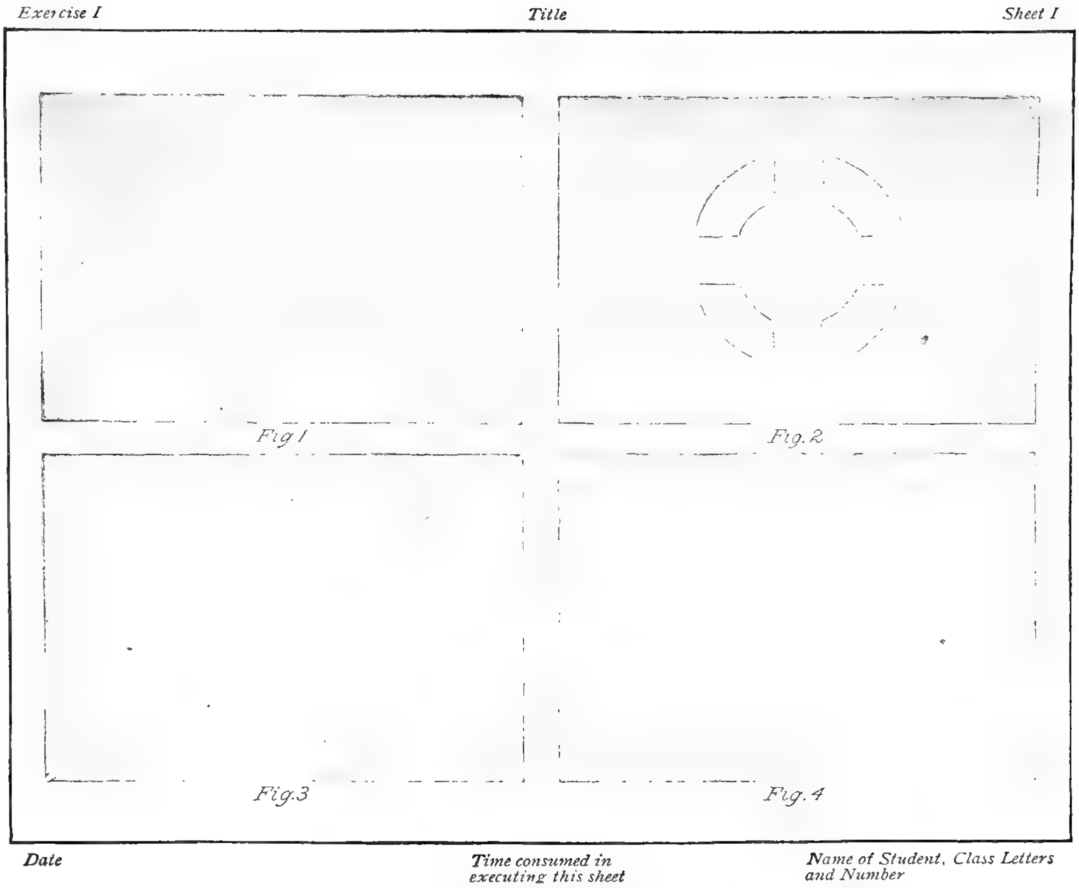
To obtain the best results on drawings where washes are required, the paper should be stretched or mounted on the board, instead of merely fastened by thumbtacks. When doing this be sure the drawing board is perfectly clean and absolutely free from greasy substance. Lay the paper "right" side up on the board. (The *right* side of any water-marked paper is that which is toward you when you can read the water mark in its proper sequence of letters. The right side of "TEC" cold-pressed paper is grained, resembling cloth; the wrong side is distinguished by minute holes or depressions.) Turn up an edge about ½ inch wide, all around the four sides of the paper, so that the paper resembles a large flat dish or tray with a raised edge. Now reverse the paper so that the wrong side will be up, the paper resting with its folded edges (reversed) touching the board. Apply library paste, with a stiff brush, to this folded edge (so that it is on the "wrong" side of the paper) and then go quickly over the paper with a wet sponge, taking care not to touch the paste. Then reverse the paper so that the right side will be up, and smooth it from the center toward the edges with a damp sponge, pressing down the pasted edges until they are sufficiently dry to adhere to the board all around. If the edge of the paper does not adhere tightly at certain places, when the paste is still moist rub it tightly into place with a flat paper knife or even with the back of the finger nail. Lay the board flat and give the paper time to dry by evaporation. Do not try to hurry it by placing it in the heat, for this will probably cause the paste to crack loose from the drawing board. The paper will at first look wrinkled and spoiled, but will soon dry and be perfectly smooth.

EXERCISE I, TITLE: FLAT WASHES

3. Exercise I, Sheet I.—Within the border line, 8 in. × 11 in., construct four rectangles each 3½ in. × 5 in., as shown in the accompanying diagram. In the upper right-hand rectangle, Fig. 2, draw two circles whose radii are 1⅛ in. and ⅝ in., respectively. Connect these two circles by


Exercise I
Title
Sheet I
Fig 1
Fig. 2
Fig. 3
Fig. 4
Date
Time consumed in executing this sheet
Name of Student, Class Letters and Number

$\frac{1}{2}$-inch vertical and horizontal bars, as shown. In the lower left-hand rectangle, Fig. 3, draw two parallel diagonal lines from corner to corner about $\frac{1}{16}$ inch apart, and in Fig. 4, draw parallel diagonals $\frac{1}{16}$ inch apart from the center of each side as shown. These subdivisions should be made with a pencil not harder than HB, and all lines except those needed to limit the surfaces to be washed over should be carefully removed by the use of a soft eraser.

4. For the purpose of washing over these areas, use charcoal gray or some other water-color paint. The best tints for the latter are ivory black and sepia. In any case, mix up a considerable quantity so as to make a liberal amount of wash, as it is nearly impossible to mix up an extra quantity to exactly the shade or tint after a small quantity is made up first and becomes exhausted.

With charcoal gray, moisten the half pan or part of the contents of the tube, and mix a few brushfuls with half a glass of water. Stir it with the brush, test on a piece of scrap paper, and allow it to dry before any attempt is made to wash in the drawings. In laying washes of any color, it is best to keep them light in tone, as evenness can better be secured in a light wash than it can in a dark one. In applying the wash, the color in the glass should be constantly stirred, as the water and pigment are otherwise likely to separate and the pigment settle at the bottom, thereby making the wash uneven in places. While in general practice it is advisable to mix the color to the exact tone required and lay it on the paper, wash drawings may be varied by laying a new wash over the old one after the latter has dried, thereby deepening its tone, as will be observed as we proceed with these exercises.

5. To wash in Fig. 1, take up as much color as possible on the No. 6 brush and apply it to the upper left-hand corner of the rectangle, as shown in Fig. 1 of the text. Care should be exercised to not let the wash extend over the edges, and to have sufficient color to secure a liberal pool at the corner of the rectangle. Tilt the board so that with the aid of the brush the color may be led to flow downwards toward the lower right-hand corner, where it should be conducted in a series of curved strokes, as shown by the dotted lines in Fig. 1 of the text. As each stroke is made, the brush should be redipped in the color and the wash carried down with a liberal supply of fluid on its lower edge. If the brush is not large enough to carry the entire pool across from the side to the corner, as from *c* to *d*, it should be carried as far as possible and redipped in the saucer; under no circumstances must the lower edge of this wash be allowed to become even partially dry as it proceeds across the rectangle for it will then leave a line. When the corner *b* is reached, the surplus color may be taken up with a dry brush, or with one from which the color has been extracted by drawing it across a blotter. Repeated applications of the brush to the blotter and to the corner of the rectangle will remove all the surplus fluid and leave the entire wash perfectly even and clean, as shown in Fig. 1 of Sheet I. As the laying of flat washes of this character is a matter of practice more than skill, it will be well for the student to repeat this exercise several times before attempting the one to be sent in for correction. The sole purpose of this exercise is to train the student to lay flat washes such as are used in architectural drawing and rendering.

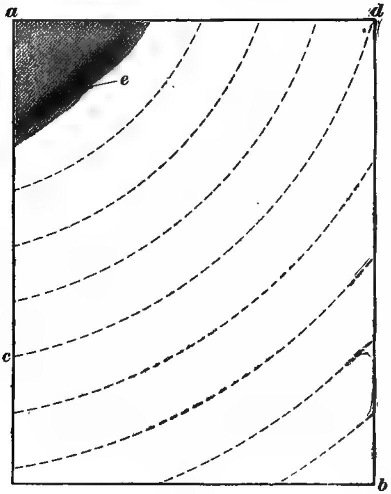


FIG. 1

6. In washing in Fig. 2, the process is precisely the same as for Fig. 1, but more care is required as the wash must be led around the circle and bars in the center without going

Exercise I *Title* *Sheet II*

Fig. 5

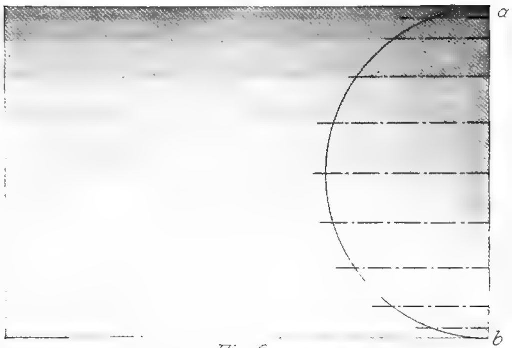


Fig. 6

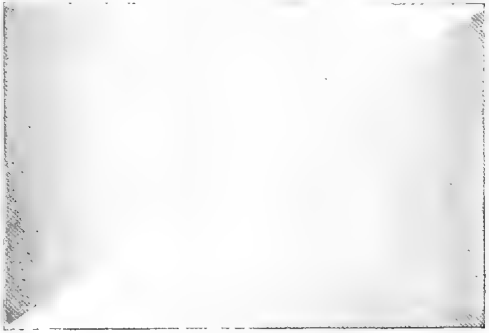


Fig. 7

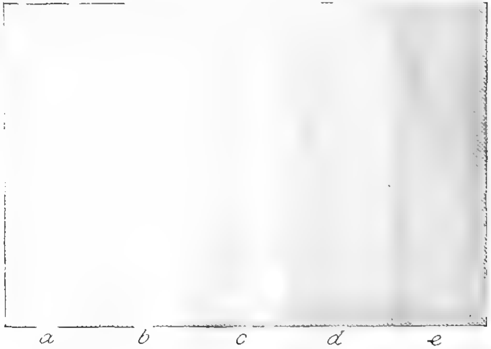


Fig. 8

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over the edges. The work is commenced, as before, at the upper left-hand corner and carried across and around the outer circle so as to leave a pool of color where the wash is to be continued, but as nearly dry as possible where it finishes against the line of the center circle. The contact of the wash with the boundary line of the white segments in the center may be kept dry by means of a brush and blotting paper in the same manner as when the corner of the rectangle is finally reached and the surplus color is intended to be removed. Figs. 3 and 4 are rendered in precisely the same manner as the others, except that great care must be exercised to see that the color does not pass over the $\frac{1}{16}$-inch space between the subdivisions, the purpose of the last three exercises being to train the hand to steadiness.

Having completed these flat washes on the four rectangles, ink in the border line, 8 in. × 11 in., trim the sheet to 9 in. × 12 in., and letter the title, FLAT WASHES, exercise number, class letters and number, etc., as heretofore. The lettering for the title and other data is to be the same as that used in *Freehand and Ornamental Drawing*. Lay this sheet aside until Sheet II is completed.

7. Exercise I, Sheet II.—The rectangles in Sheet II of this exercise are laid off as were those on Sheet I, and should be subdivided as follows: Draw through Fig. 5, four horizontal lines equally spaced, so as to divide the rectangle into five equal bands, or stripes. On the end of Fig. 6 describe a semicircle whose diameter $a\,b$ will be equal to the end of the rectangle, that is, $3\frac{1}{2}$ inches. Divide the circumference of this semicircle into ten equal parts and through the points of division draw horizontal lines the full length of the rectangle, as shown. This will divide the rectangle into ten bands of varying widths in proportion to the receding arcs of the semicircle. Fig. 8 is divided similarly to Fig. 5, except that the lines of subdivision are vertical, and Fig. 7 like Fig. 3, Sheet I.

8. The graded washes in Figs. 5, 6, and 8 are laid by repetition; that is, all four rectangles are first washed over with a plain wash, identically the same as in Fig. 1. After these are *thoroughly dry*, a second wash is laid over the rectangle with the omission of one of the subdivisions as shown, and when this is dry a third wash is laid omitting another subdivision. In this way we have, in Figs. 5 and 8, one wash at *a*, two at *b*, three at *c*, etc. In Fig. 6, the washes are graded in tone, thus presenting the appearance of a rounded or prismatic surface. The sections of the rectangle being divided at projections from the semicircle, the appearance of the curve is very marked, and to enhance this effect the washes are laid so that they grade in each direction from the lightest wash, which is on the third rectangle from the bottom, but on the dark side of the rectangle the heaviest wash is found at *a*, where there are eight applications, while below it there is one less as each subdivision is passed. The work in Fig. 7 is similar in effect to Figs. 5 and 8, but much more difficult in application.

Graded washes, as in Fig. 7, are laid by first applying the top tone on the upper edge of one of the triangles with the brush charged with very dark color. This wash is carried down about one-fourth the depth of the triangle from the edge, that is, the edge that is being worked from. The pool at the bottom of the wash remains as usual while the tip of the brush is redipped in clear water and added to lower edge of this pool so as to dilute it, and the wash is carried somewhat farther. Again the brush is dipped in water and the diluted wash is carried still farther until the bottom of the triangle is reached and the tone is almost clear water. In this way, the color grades from dark to light. The lower half of Fig. 7 is similar in appearance but reverse in effect. Here the wash is applied in its lightest tone first and additional color is added to it to deepen the tone as the pool is carried over the plate. When the lower side is reached, the darkest tone is applied. Precisely similar results can be obtained by either of these methods, but it is occasionally more convenient to use one than the other. The ability to lay graded washes of this character gives confidence to the student and trains him to understand his color and appreciate

Exercise II *Title* *Sheet I*

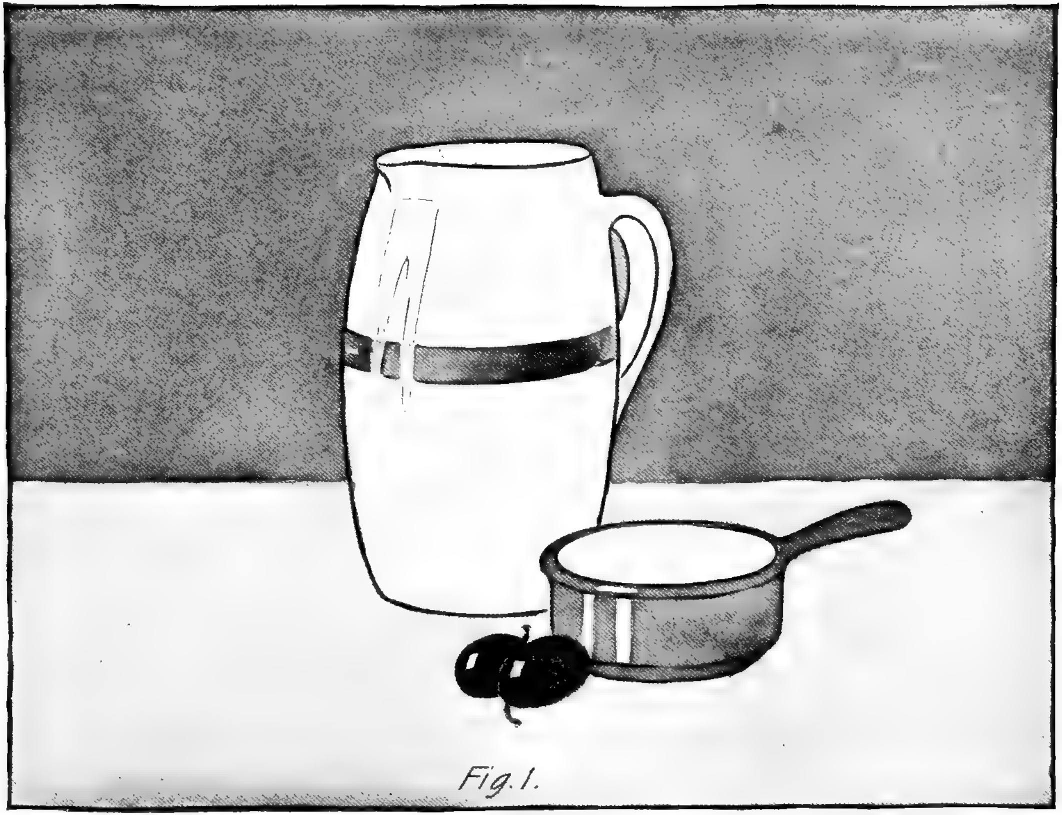

Fig. 1.

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what can be done with it. Fig. 8 is executed in precisely the same manner as Fig. 5 except that the bands are vertical.

Having completed these flat washes in the four rectangles, ink in the border line, 8 in. × 11 in., trim the sheet to 9 in. × 12 in., and letter the title, FLAT WASHES, exercise number, class letters and number, etc., as heretofore. The lettering for the title and other data is to be the same as that used in *Freehand and Ornamental Drawing*.

The two sheets of Exercise I are now mailed *flat* to the Schools for correction.

EXERCISE II, TITLE: WASH DRAWINGS

9. The rendering of this exercise, although somewhat different in method from any of the previous ones, is dependent none the less on identically the same principles.

In wash drawing, it is necessary to use several values, or tones, and it should be remembered that these values should be produced directly; that is, one wash of the proper depth of tint should be used instead of several washes laid over one another. The direct method gives a snap and crispness to the drawing that is impossible to obtain by means of a series of washes.

In wash drawing there are no outlines. In certain conventional renderings, such as Sheet I of Exercise II, the outline is inserted as a part of the design, but observe in Sheet II the entire form is expressed by a series of graded washes adjacent to one another without any individual outline being expressed. It seldom occurs that one need employ more than five values in order to express what is desired in his picture.

10. Exercise II, Sheet I.—The medium, or material, in which Sheet I is rendered is charcoal gray, although for some monochrome rendering, sepia is used, occasionally tempered with a little Vandyke brown or burnt sienna to lighten or deepen its tone. The washes for the plate may be mixed in an ordinary saucer, or a special water-color dish with several compartments. It is best to have two or three small dishes to contain the different washes representing different values, although after the student becomes experienced and skilled in the use of the wash he will be able to mix these values readily by adding more color or more water to the solution that has already been prepared. A blotter should be close at hand in order that the brush may be quickly dried, when occasion demands it, and a small, soft, wet sponge will be found exceedingly handy for wiping off a bad wash before it gets dry.

11. To draw Sheet I, the student should make the enclosing rectangle 8 in. × 11 in. This figure indicates a simple treatment in flat tones of a still-life study, and contains five values including the white and the black. No attempt has been made to render actual light values, except where the small patches of white indicate where the strongest light falls on the objects. Observe how much can be expressed by the simple suggestion of these high lights, and study their location in still-life objects in order that they may be put in their proper places.

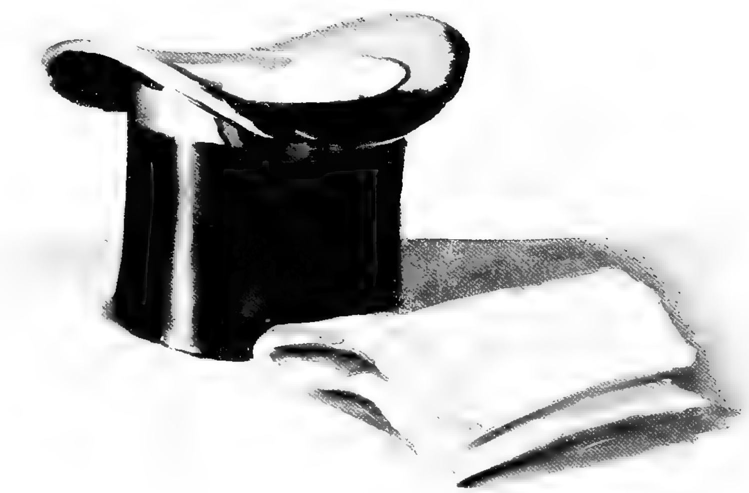
The best method of executing this drawing will be to make a careful drawing in pencil on another piece of paper and then carefully trace and transfer it to its proper place on the drawing sheet that is to be sent in for criticism. This is advised because, when washes are to be applied to the paper the surface must be perfectly smooth and even, and if much rubbing is done, in order to correct the drawing, the washes will not flow evenly.

The success in the rendering of this figure depends as much on the accuracy and truth of the facts as on the smoothness of the washes; truth in values can be obtained only by painstaking care, in experimenting with each wash and matching it carefully with the scale of value desired. Smooth washes can be obtained only when the wash is laid rather quickly and spread over the surface evenly before any portion has had an opportunity to dry. The board should be held in a slanting position toward the worker, and the wash begun in the upper left-hand corner and carried down from

Exercise II

Title

Sheet II



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Name of Student, Class Letters and Number

left to right. When the wash is completed and the surplus color has reached the lower right-hand corner, the brush should be dried on the blotter and the point applied to the wash to absorb the superfluous moisture. Care must be taken on this figure that one wash is thoroughly dry before the next one is laid beside it, otherwise they may run together. Sometimes it is desirable to have them do this. The high light on the pitcher should be expressed by allowing the white paper to show, and *never* by using Chinese white. The dark outline in this figure is executed, after all the washes are dry, with the point of the brush.

The sheet should now be trimmed to 9 in. × 12 in., and the exercise number, sheet number, student's class letters and number lettered in as before.

12. Exercise II, Sheet II.—In Sheet II, the rendering will be more complicated because the expression of light and shade is added to that of the color value and the shades are graded and vignetted into one another. In applying the wash to this drawing, the principal object should be considered first; that is, the silk hat. First, lay the light gray wash inside the band, leaving the patch of white where the high light falls. When this is nearly dry, add the middle value to the rim and the ribbon and down the high light of the crown. Before this latter is quite dry, the deep black should be applied so that it will spread into it slightly and not produce a hard line where the high light and the dark portion come together. If there is a tendency for the black to spread too much, it is a sign that the half tone is too wet, and the tendency to spread may be lessened by touching it slightly with the edge of a piece of blotting paper. The rest of the crown should now be laid in, and the very slightly reflected lights on the side of the hat may be produced by absorbing with the blotter the excess of color that gives the deadness of tone. The softening of washes at the edges, where such is desirable, so that a dark tone may gradually blend into a light one, is usually effected by rinsing the brush in clear water and then gently drawing it along the edge of the still wet wash that is to be softened. In this way a dark tint may be gradually washed down almost to pure white.

Another way of vignetting the dark tint into the light tint is to wet the paper before the dark tint is applied. Where a light gray tint is to be washed into a lighter tint, this is the better method, because the entire surface may be moistened with clear water, and then the gray tint worked into the center of it wherever desired, and the edges afterwards softened off so that no line of demarcation exists between the white paper and the gray tint.

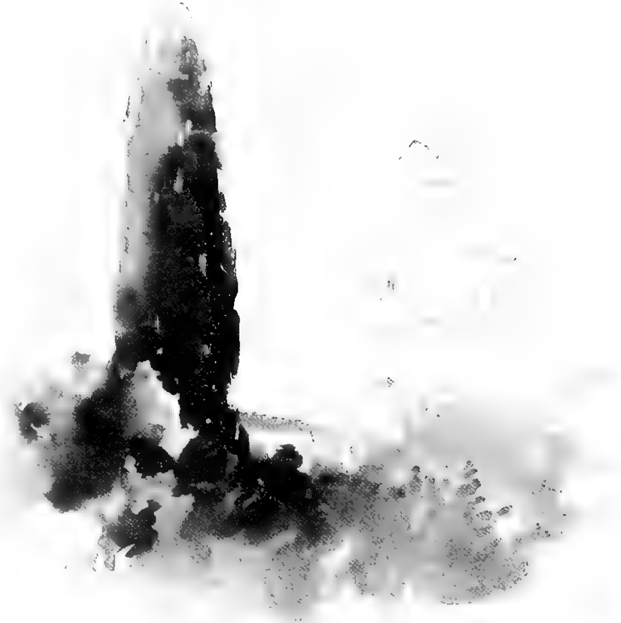
The usual border line 8 in. × 11 in. is then drawn freehand, with the point of a fine brush, and in the medium used on the darkest tone of the hat. The proper lettering is also placed on the margin and the sheet trimmed to 9 in. × 12 in., and laid aside with Sheet I.

13. Exercise II, Sheet III.—Sheet III is a small sketch of part of one of the California Mission Buildings. The only new thing in this figure is the rendering of the foliage, which is extremely crude and suggestive. The principal object is the tower and dome, which should be drawn first. There are two shades of gray on the sides of the dome, and the windows are one tone darker. In rendering the foliage, begin with middle gray and soften it at the edges where necessary in order not to make it too harsh. The black on the poplar tree should be added while the middle gray is still moist, in order that it may spread and produce a soft effect at the edges. The slight suggestion of outline around the dome of the tower and along the eaves and string courses should be introduced in order to preserve the architectural effect of the building, in contrast to the sketchy foliage.

The freehand border line 8 in. × 11 in. is drawn as on Sheet III, and the usual lettering inserted at the proper places. The sheet is then trimmed to 9 in. × 12 in. and then laid aside with Sheets I and II.

14. Exercise II, Sheet IV.—Sheet IV is a problem in rendering similar to that on Sheet III, but slightly more

Exercise II Title Sheet III



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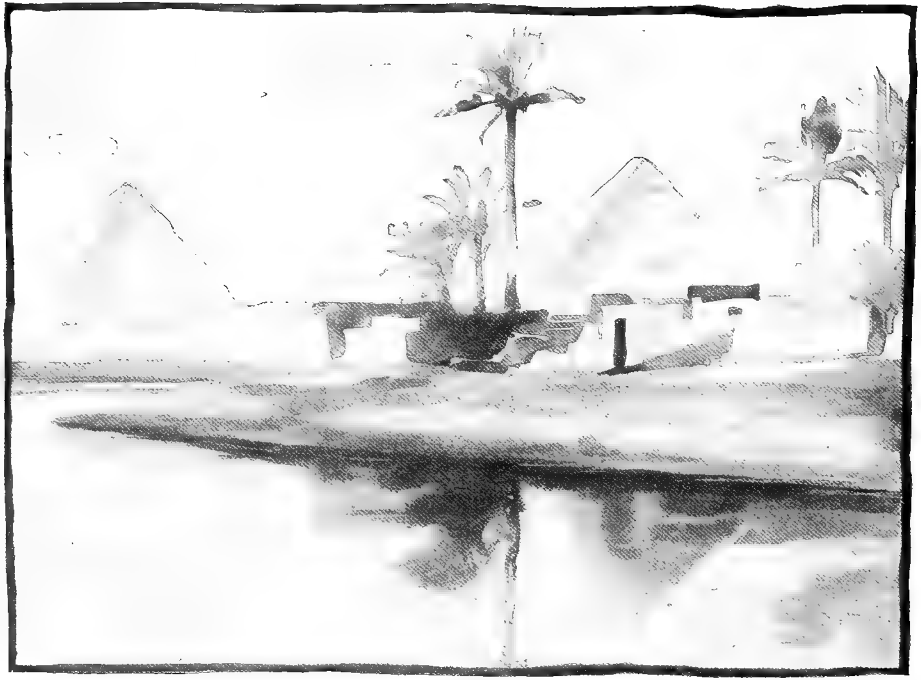
Exercise II *Title* *Sheet IV*



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Exercise III *Title*

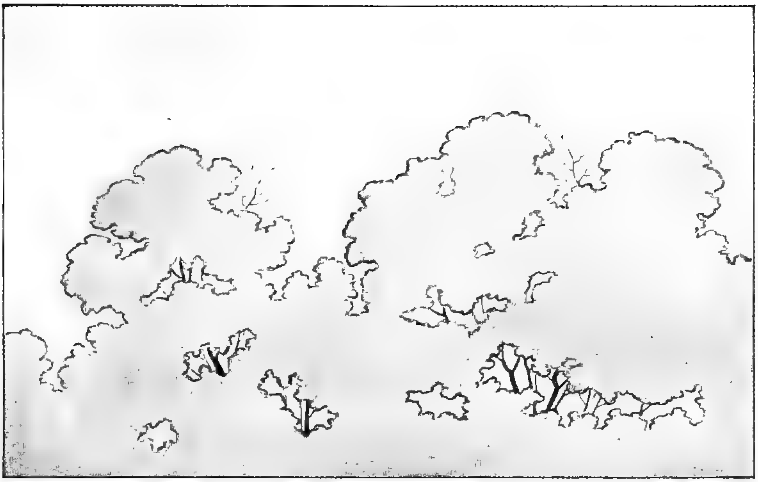

Fig 1

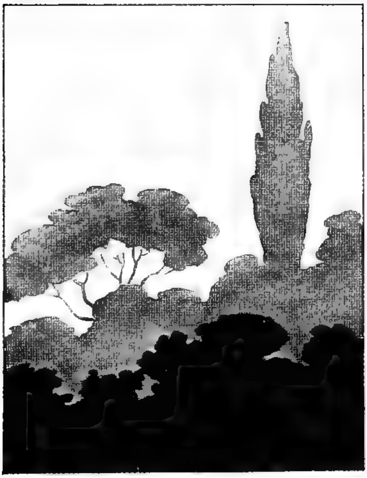

Fig.2

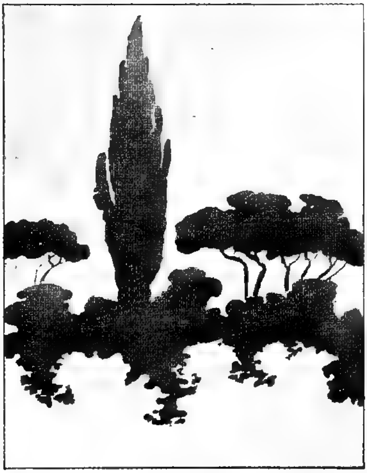

Fig 3

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Name of Student, Class Letters and Number

difficult. The two sides of the pyramids are expressed in two tones, and the other details of the landscape are rendered in tones that give them contrast and variety of effect. This problem should be studied carefully and rendered according to the principles described. There is nothing in it differing from the preceding ones, except the rendering of the water and the reflections. To render these reflections, either of two methods may be employed. First, the paper should be dampened with clean water and then the dark tones of the reflections washed in, the edges being still further softened off with a moist brush. After these are thoroughly dry, the body tone of the water should be washed over the entire space that it is to occupy, including the dark tones of the reflections previously placed. Or, second, the main body tone of the water should first be washed in and allowed to become almost dry, but not entirely so. The dark tones of the reflections should then be washed in over the moist background, the edges of the reflections blending softly into the background. This method should also be used for the clouds. These reflections must be repeatedly practiced on separate pieces of paper before the final sheet is rendered.

The inside border line should be made with a broad solid brush stroke, while the main border line 8 in. × 11 in. is drawn as before, and the usual lettering included. The four sheets of this exercise should then be mailed *flat* to the Schools for correction.

EXERCISE III, TITLE: ARCHITECTURAL TREES AND SKIES

15. Exercise III will be executed on one sheet of the usual size—9 in. × 12 in., with the border line 8 in. × 11—the three drawings taking up the entire space.

The outline of the trees in Fig. 1 should be sketched in very lightly with a soft pointed pencil, as also the openings in the foliage, as shown. Then with a wash of gamboge, to which a little new blue has been added, the space occupied by the foliage should be deliberately washed in. This wash should *not* be mixed in a saucer and applied as an even wash, as was the case with Exercise I, Flat Washes, but the two colors composing it should be taken into the brush and mixed as they are spread across the paper. A variation of tone and color is thereby secured, and a degree of transparency exhibited that would be impossible if the colors were mixed thoroughly before being applied. The outlines of the foliage and the openings therein may be emphasized with the point of the brush charged with burnt sienna and the suggestion of branches also expressed. The sky is rendered by thoroughly wetting the upper part of the sheet with clear water, and while the surface is still quite damp applying new blue in light irregular washes as shown. Do not try to get absolutely flat or even washes in any of these figures. If the washes turn out flat, let them be so, but if they are mottled, do not go over them. One style is as good as the other.

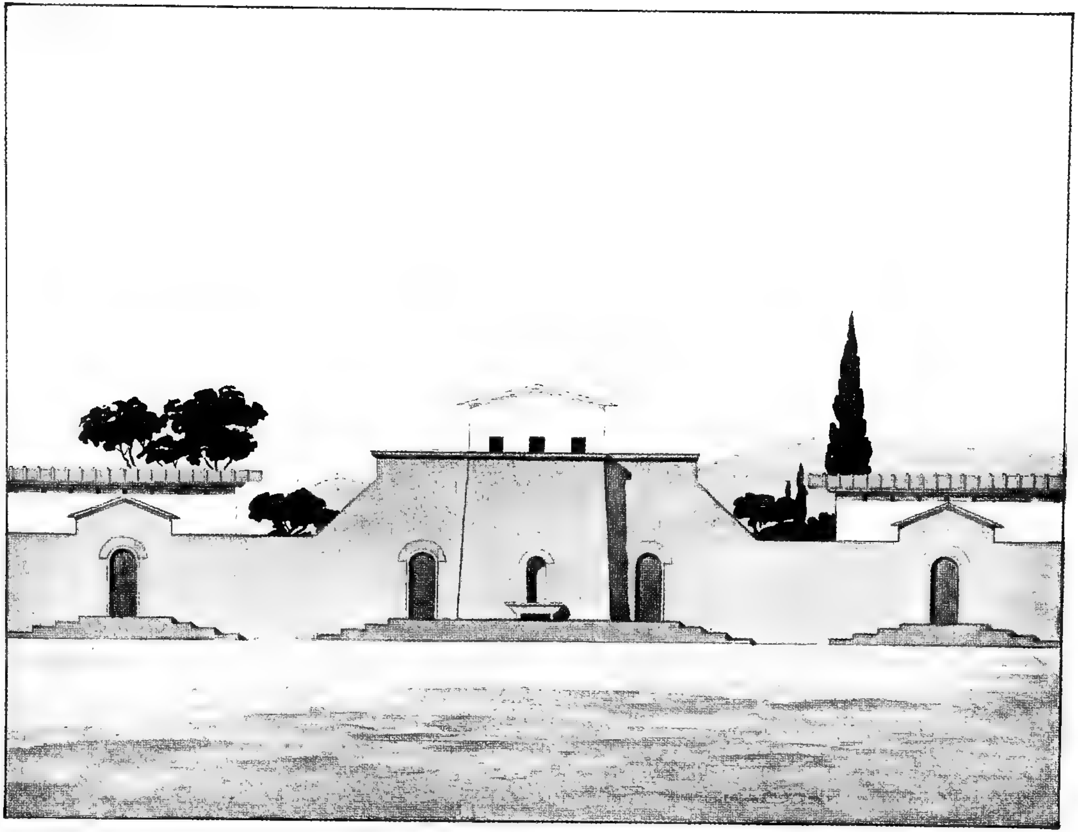
In Fig. 2, the outline of trees should be lightly indicated as stated and the purple wash applied with a mixture of crimson and new blue, while the dark green wash in the foreground is made with gamboge and Prussian blue. The foliage here is made by means of a series of rapid strokes, the intention being to express an effect without absolute detail. In Fig. 3, a similar procedure is carried out, but the general foliage is drawn with gamboge and Prussian blue. The foreground is expressed by a light wash of burnt sienna and the sky is worked in on dry paper with new blue or cobalt.

In executing this exercise, it is not the intention that the student should copy. Architectural trees and skies are added to drawings in order to produce effect, and their conventional character does not require that they should be worked up in any detail. The student should bear in mind that any variation that can be made from the examples sent him will be to his advantage, and the exercises sent in for criticism and correction should be the exercises of his ingenuity and originality, as well as of his skill with the brush, and not a copy.

This sheet, Exercise III, should be lettered as usual, trimmed to 9 in. × 12 in., and mailed to the Schools *flat* for correction.

Exercise IV

Title



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EXERCISE IV, TITLE: RENDERED ELEVATION

16. For Exercise IV, draw horizontally across the 8″ × 11″ rectangle of the drawing sheet a line $1\frac{3}{4}$ inches above the lower border. On this line construct the elevation of the wall and the building as shown. Carefully take the measurement of each detail in the elevation and transfer it to your drawing sheet double the scale. The trees and distant mountains can then be sketched in freehand. When all is carefully outlined in pencil, a graded wash of burnt sienna should be carried over the entire front wall as shown. This wash should be darker at the top and grade lighter toward the bottom. A second wash, to indicate the shadow to the right of the central buttress, should then be laid, but graded so as to be darker at the bottom than at the top. This same depth of tone can be used for the three sets of steps in front of the doors, while the doors themselves should be a shade darker. A deeper shadow appears on the left side of the door opening and under the coping of the wall. The buildings behind the wall are tinted with a pale wash of gamboge and the roofs are vermilion with darker streaks of India red and vermilion to indicate the tile joints. Now wash in the distant mountain with Prussian blue and crimson (very pale), and when this is dry lay in a pale wash of new blue or cobalt for the sky. Turn the board upside down when washing in the sky, and commence the sky line on the house roof and mountains with a very pale tint, gradually strengthening the tint until the border line is reached, at which point the sky should be darkest in tone. Lastly, draw in the trees and foliage with Prussian blue and gamboge.

Having lettered this sheet as usual and trimmed it to 9 in. × 12 in. as before, it should be mailed *flat* to the Schools for correction.

ELEMENTARY PERSPECTIVE DRAWING

INTRODUCTION

OBJECT OF PERSPECTIVE DRAWINGS

1. Classification of Perspectives.—A **perspective drawing** of an object is a representation of that appearance, in outline, which an object presents when observed from a given point. If the perspective is rendered in outline only, it is known as an **outline perspective**; but if it is shaded, in order to express the light values of different parts, it is a **shaded** or **rendered perspective.** A perspective drawing may thus be rendered in "black and white," as with crayon, pencil, or India ink, or it may be rendered in color. A photograph of an object is a perspective rendering of that object in black and white, and a similar effect may be obtained by a combination of lines and shaded surfaces, the proportions of which are readily learned through graphic methods.

All objects are bounded by plane or curved surfaces and all surfaces are limited by lines. Therefore, the drawing on paper of these limiting lines, as they appear to the eye, determines the apparent shape and area of any surface; and the grouping of all the visible surfaces bounding an object produces a perspective rendering of that object.

2. In making projection drawings, it is assumed that the eye is always in front of each particular portion of the object,

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no matter how large it may be, and that the form projected in the plan is derived from outlines obtained by projecting each important point of the object to the drawing paper or to a **plane,** held in a vertical or horizontal position, according to whether the elevation or the plan is being made. In Fig. 1 is shown the application of this principle for a small building where the front elevation, side elevation, and plan are shown

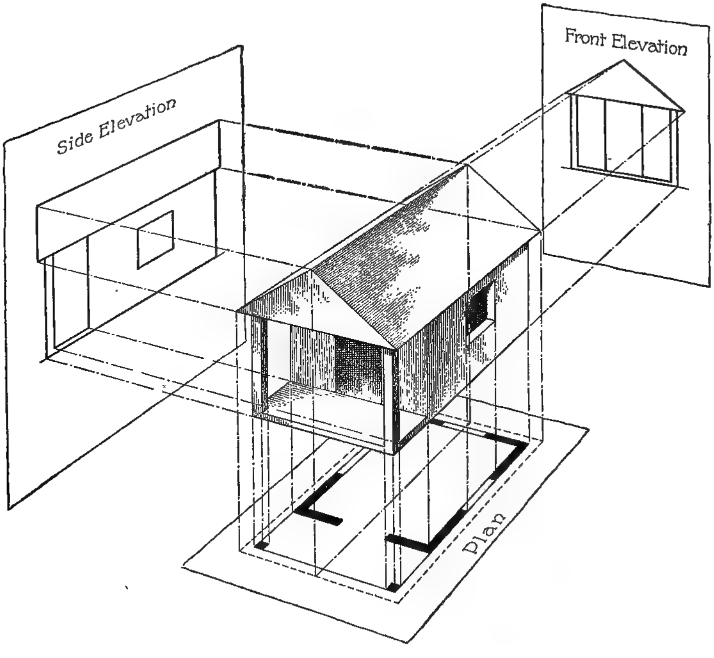


FIG. 1

on three sheets to which they have been projected by imaginary lines drawn from the several parts of the building.

In some respects, a perspective drawing is similar to a projection drawing, but the plane on which the drawing is expressed is assumed to be *between the eye and the object.* In perspective drawing, this plane is called the **picture plane,** and the point from which the object is viewed is called the **station point.**

SIZE OF PERSPECTIVE

RELATION OF ANGLE OF VISION TO SIZE OF PERSPECTIVE

3. The relative sizes of the parts of an object, as expressed on the picture plane, are dependent on simple mathematical rules that determine the apparent sizes of different objects, according to their distances from the eye.

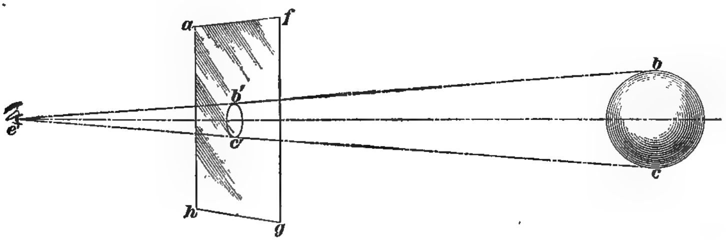


FIG. 2

Referring to Fig. 2, if it is assumed that lines are drawn from each side of the sphere bc to the eye at e, and that these lines are intercepted by a transparent plane, as shown at $afgh$, the circular outline connecting the points $b'c'$ where the lines eb and ec pass through the plane $afgh$ will form, on this intercepting plane, an outline of the sphere bc; but this outline varies in size, according to the distances that the plane $afgh$ and the sphere bc are from the eye.

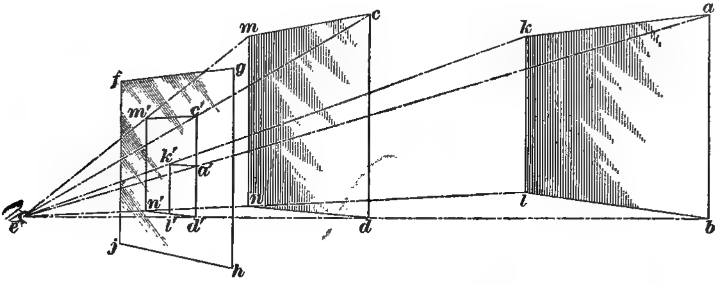


FIG. 3

4. From the foregoing, it will be seen that the nearer an object is to the eye, the larger it will appear on the picture plane, as is shown in Fig. 3, where *a b* and *c d* are sides of two rectangles and are of the same length, but their apparent sizes on the picture plane *f g h j*, as viewed by the eye at *e*, are different; the line *c d*, being nearer the eye, appearing larger, as shown at *c′ d′*. From this, the following rules may be deducted:

Rule I.—*The length of any line seen on the picture plane varies inversely as the distance of that line from the eye.*

Rule II.—*The area of any surface on the picture plane varies inversely as the square of its distance from the eye.*

Thus, in Fig. 3, *a b* being double the distance from *e* that *c d* is, appears only one-half the size of *c′ d′* on the picture plane *f g h j*, as shown at *a′ d′*; and the area of the rectangle *a b l k* appears on the picture plane only one-fourth the area of the rectangle *c′ d′ n′ m′*, as shown at *a′ d′ l′ k′*, as each of its dimensions is apparently reduced one-half. If the distance *e b* were four times the distance *e d*, *a′ d′* would then

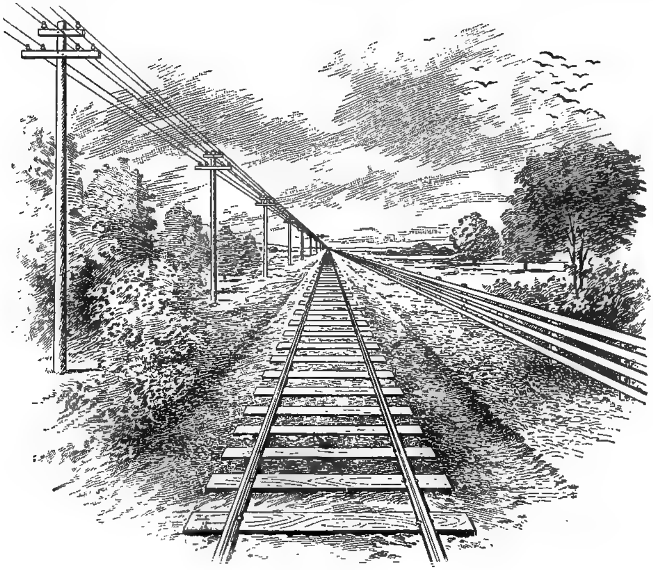
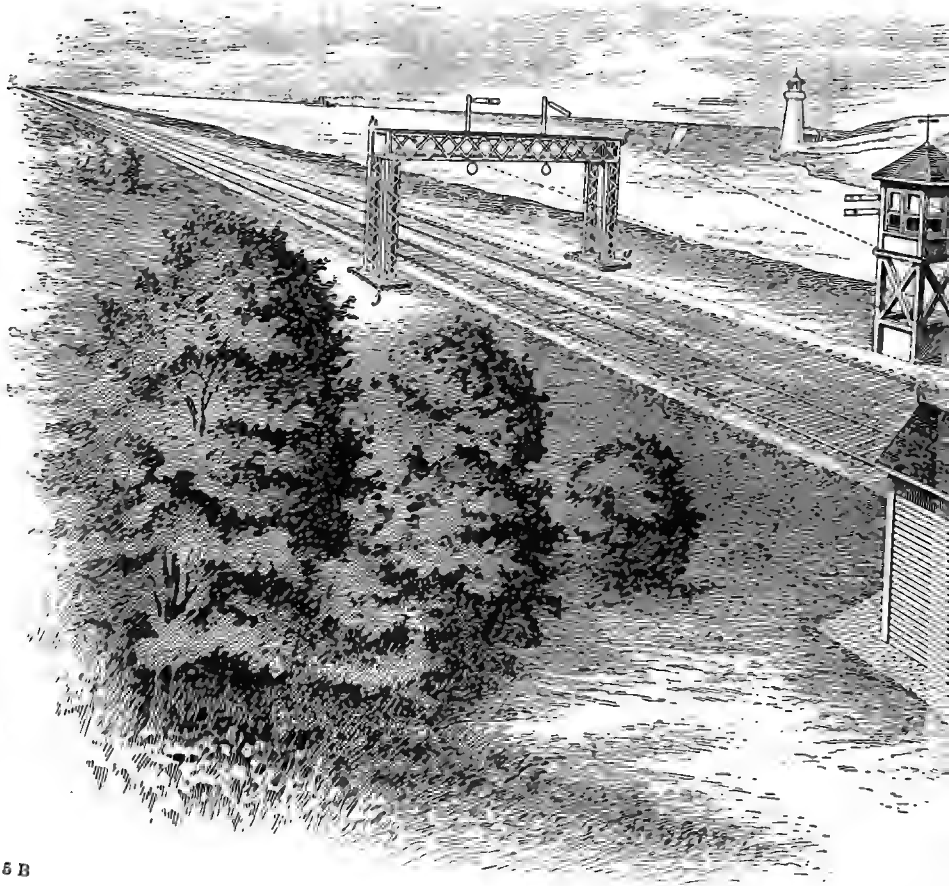
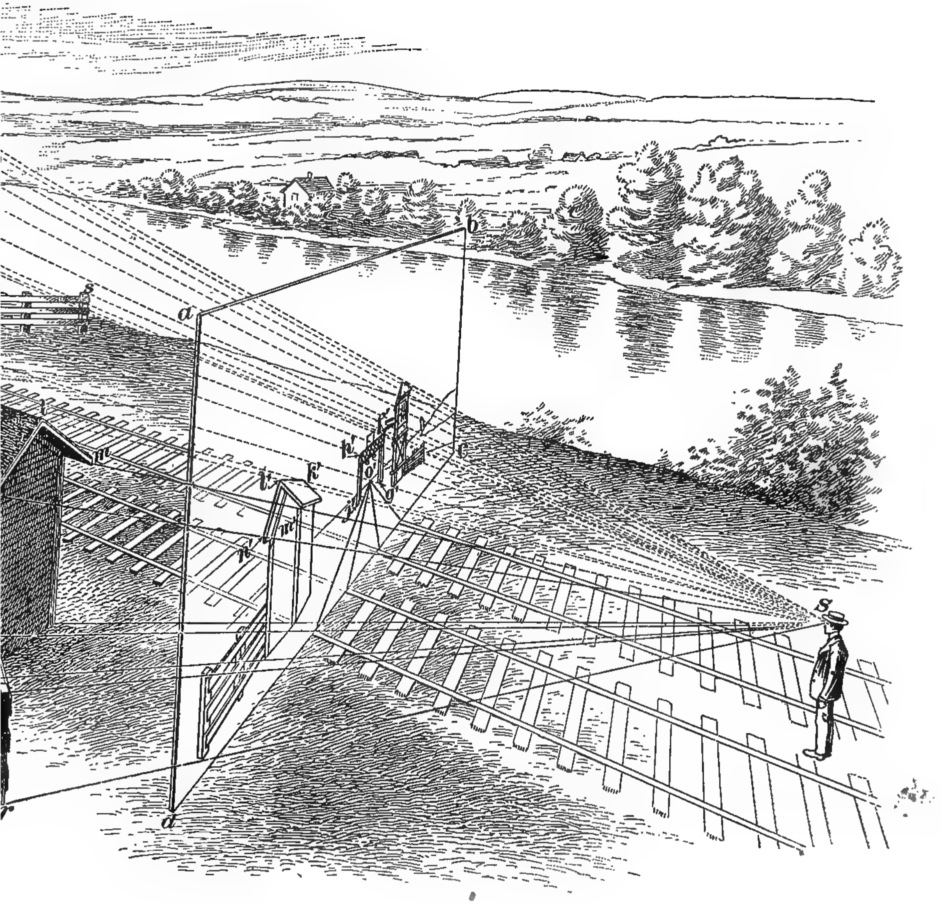


Fig. 4



5 B

Fig. 5



§ 5

appear only one-fourth $c' d'$, and the area $a' d' l' k'$ would then be but one-sixteenth the area $c' d' n' m'$.

5. This fact is illustrated in a practical way when one stands in the center of a straight section of railroad track. On looking up the track, the rails appear to converge and meet at a point in the distance, as shown in Fig. 4, while on looking above at the wires on the telegraph poles, they appear to converge and disappear at the same point, and the lines of the fence boards at the side of the track all diminish and finally disappear in the distance in a similar manner. The apparent width of the track obeys the first rule just set forth, and the rails finally meet in a point at an infinite distance away.

6. The picture plane may be further illustrated by assuming an open landscape that includes a railroad track, as shown in Fig. 5, and a semitransparent screen $a b c d$ placed vertically on the ground; then, by standing back of it, in the center of the railroad, the landscape may be viewed through the screen from the viewpoint S. The semitransparent screen is then the picture plane and S is the station point. Imaginary lines drawn from the eye to each of the prominent features in the landscape will pierce the picture plane at certain points, which points, being connected on the picture plane by actual lines, will render a linear, or outline, perspective of the scene, each line of which will coincide with and cover its corresponding line in the actual scene.

For instance, in Fig. 5, a line $f S$ from the upper right-hand point of the signal bridge at f to the eye at S pierces the screen at f', and the line $g S$ from the lower right-hand point of the signal bridge to the eye at S pierces the screen at g'. The upper left-hand point of the bridge at h and the lower left-hand point of the bridge at j form the ends of lines that pierce the screen at h' and j' and meet the eye at S. Lines connecting the points f', g', h', and j', therefore, cover and coincide with the respective lines between these points on the bridge itself, and establish the outline of this bridge as seen on the picture plane. In the same manner, the points *k*, *l*, *m*, and *n* of the ridge and eaves of the roof over the little tool house are expressed in the perspective on the picture plane by the points *k'*, *l'*, *m'*, and *n'*, where the lines *k S*, *l S*, *m S*, and *n S* pierce the picture plane *a b c d*.

APPARENT CONVERGENCE OF PARALLEL LINES

7. Horizontal lines that are parallel with the picture plane always appear parallel in perspective, as shown by the ties of the railroad track, Fig. 4, which appear to diminish in length and in distance apart, but remain parallel with each other, until they disappear in the distance. The same is observable in the telegraph poles and fence posts. Hence, the following rules are deduced:

Rule I.—1. *All lines parallel with the picture plane, whether vertical, horizontal, or inclined to the ground line, retain their normal directions in perspective drawing:*

2. *All lines or surfaces of objects in contact with the picture plane appear their full normal size in perspective drawing.*

3. *All lines or surfaces of objects beyond the picture plane appear smaller than normal in perspective drawing.*

4. *All lines or surfaces beyond the picture plane and parallel with it can be drawn to the same scale; but smaller than those in contact with the picture plane.*

Rule II.—1. *All lines not parallel with the picture plane, but parallel with one another, appear to converge as they recede from the eye. The point toward which any set of parallel lines converges is called their vanishing point.*

2. *When the parallel lines are perpendicular to the picture plane* (as the rails, telegraph wires, and fence boards in Fig. 4), *the vanishing point is directly in front of and on a level with the eye; in this position it corresponds with the center of vision.*

Hence, lines perpendicular to the picture plane and below the level of the eye slant upwards, as shown by the rails, and lines above the level of the eye slant downwards, as shown by the telegraph wires.

The horizontal line on the picture plane through the center of vision is called the **horizon,** and the line from the eye to the center of vision is called the **axis,** or **line of direction,** and the extent of the view that is included on all sides of the line of direction is called the **field of view,** or **angle of view.** As the eye is only capable of including about 60°, the field of view is usually limited to include but 30° each side of the line of direction. When so limited, the field of view is termed the **visual angle,** or **scope of vision.**

Rule III.—1. *When the parallel lines are horizontal, but at an angle with the picture plane, their vanishing point is on a level with the eye, but to the right or left of the center of vision, according to the angle that the lines make with the picture plane* (as shown by the fences at *r* and *s* in Fig. 5).

2. *When the parallel lines are horizontal and incline at an angle of 45° to the picture plane, their vanishing point is to the right or left of the center of vision* **a distance equal to the distance of the station point from the picture plane.**

8. This can be more clearly illustrated by means of an ordinary 45° triangle on which lines are marked as in Fig. 6. Let the long side of the triangle *L R* represent the horizon,

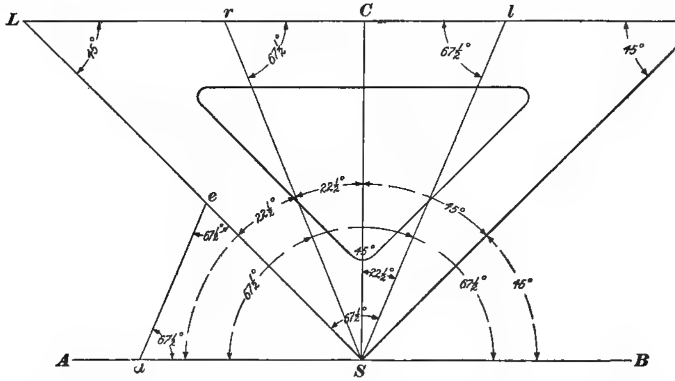


FIG. 6

and the corner *S* represent the station point; then, *S L* and *S R* will represent lines at angles of 45° with the horizon, and *S C* a line perpendicular to the horizon. *L* and *R* will be the vanishing points of 45° lines, and *C* will be the vanishing point of perpendicular lines. If the angles *CSR* and *CSL* are bisected, and the bisecting lines are carried to the horizon, the points *l* and *r* will be located. These are the vanishing points of these bisecting lines. In the same manner, the location of the vanishing point of any other line might be determined if wanted. *AB* is a line parallel with the horizon and would have no vanishing point in the picture plane; therefore, it would be parallel with the horizon in perspective.

Now, if this same triangle were drawn in perspective, no matter what its position to the right or left of the center of vision, these same lines would vanish in the same points enumerated in the horizon, as shown in Fig. 7, where at (*a*) the perspective view of the triangle is shown below the horizon and to the left of the center, at (*b*) above the horizon and to the right of the center, and at (*c*) below and in the center.

9. It will be observed that the closer the perspective view of the triangle approaches the horizon, the less of its surface is seen. When the view is exactly on the horizon, only its edge can be seen. Above the horizon its under side is visible, and below the horizon the upper side is seen.

With the location of these points on the horizon, the vanishing points of all the sides and two diagonals of a square or an octagon, as shown in Fig. 8, are had, which are very important details, as will be shown hereafter. However, the points *r* and *l* are not regularly used as vanishing points, but as points by which measurements of receding lines may be obtained; therefore, they are termed **measuring points.**

Now, in Fig. 6, the distances *Se* and *Sa* are laid off on the triangle and on the line *AB*, and the line *ae* is drawn making *aeS* an isosceles triangle. *SLl* is also an isosceles triangle, and the lines *Ll* and *aS* are parallel; therefore, the lines *ae* and *Sl* are parallel.

In perspective all parallel lines vanish at the same point. Therefore, if the length of the side of the triangle is

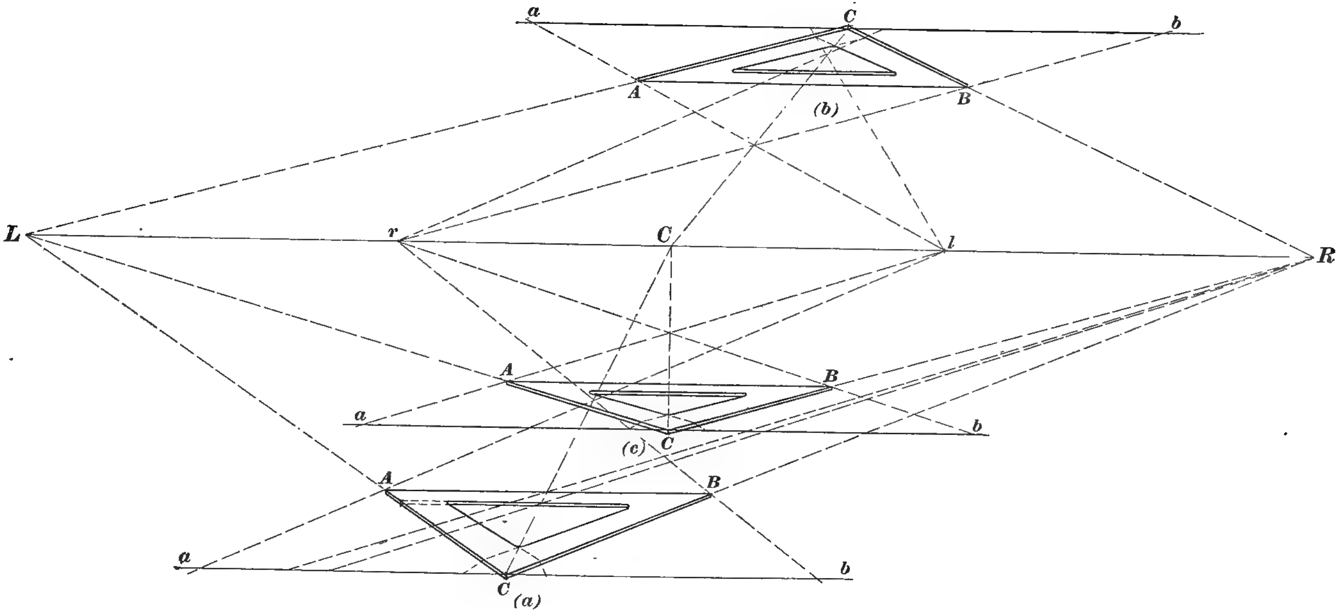


Fig. 7

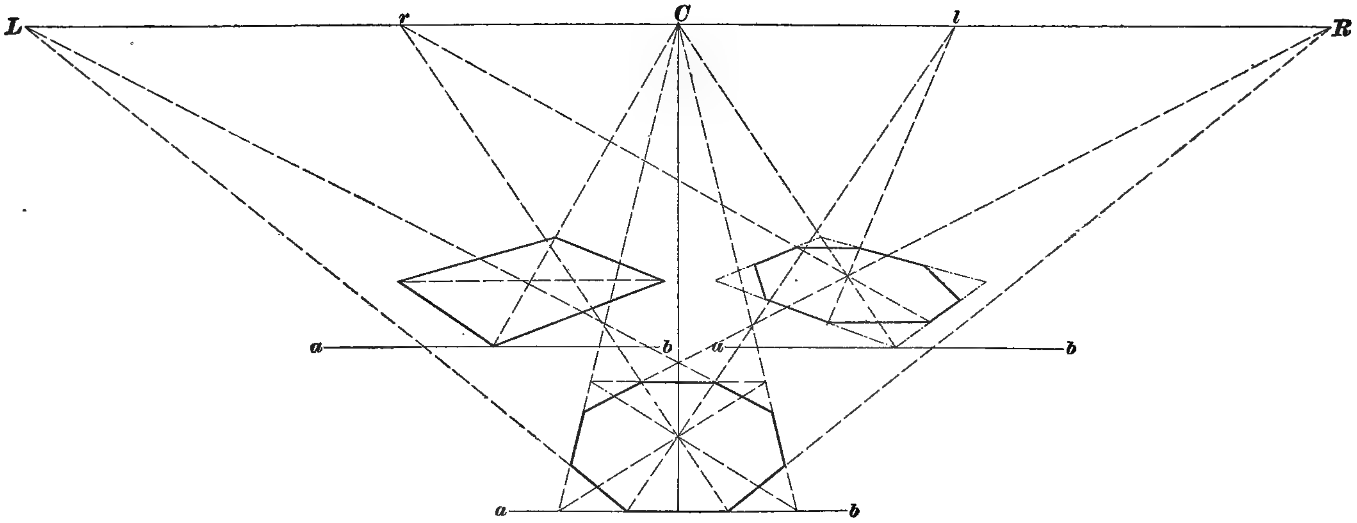


FIG. 8

laid off from *C* to *a*, Fig 7 (*a*), it can be transferred to the perspective drawing by projecting a line to *l* to cut the vanishing side of the triangle at *A*. In this same manner any dimensions can be determined on lines from *C* to *L* and *R* by projecting them from the measuring line toward *l* and *r*.

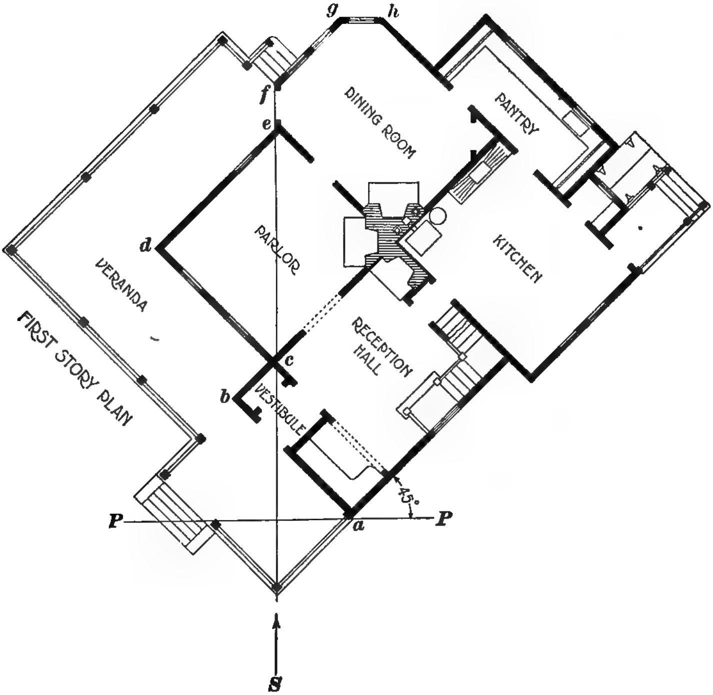


FIG. 9

10. In Fig. 9 is shown a plan of a small house, the corner of which *a* is in contact with the line *PP*, *PP* representing the plan of the picture plane on which this plan in perspective is about to be represented. The angle between the house line and the line *PP* is 45°. Then, one side of the bay window *fe* will be perpendicular to *PP*, and the other side *gh* will be parallel with *PP*. All the other main lines of the building will be at an angle of 45° with *PP*.

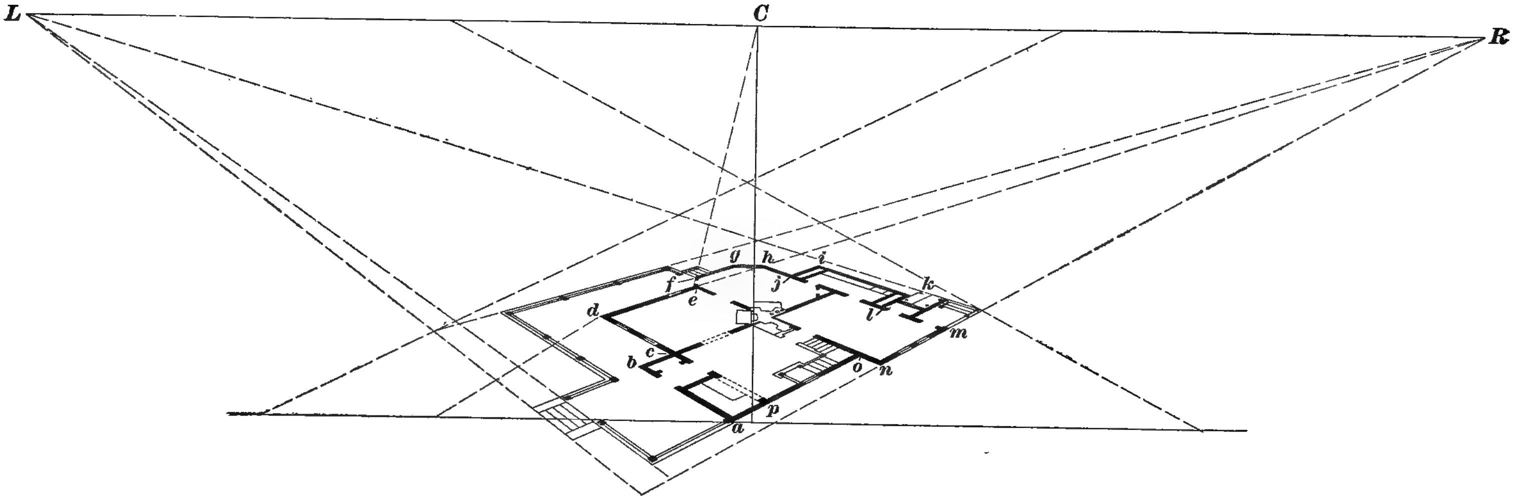


FIG. 10

Now, in Fig. 10 are shown the horizon and three principal vanishing points; fe, which is perpendicular to the picture plane in Fig. 9, must therefore vanish at C in Fig. 10, as all lines perpendicular to the picture plane vanish at C; and gh, which is parallel with the picture plane in Fig. 9, is parallel with the horizon in Fig. 10, as all horizontal lines, parallel with the picture plane, are parallel with the horizon in that picture plane. All other lines in the plane are at an angle of 45° with the picture plane, and therefore vanish at L and R.

11. In Fig. 11 is again shown the illustration of the 45° triangle, with the plan of the small house laid out on its right angle. The line AB is drawn parallel with LR. The corner of the house corresponds with the angle S of the triangle. Now, if l and r are located on the line LR so that Ll and Rr are equal to LS and RS, respectively, the plan may be laid out as follows: On AB lay off $Sa_1 = 17' 0''$ and $a_1 b_1 = 15' 0''$. Then, draw $a_1 e$ and $b_1 h$ parallel with Sl; where these lines intersect SL they will lay off the distances Se and Sh exactly equal to Sa_1 and Sb_1. In the same manner, Sc_1 is laid off to the right $= 16' 0''$ and $c_1 d_1 = 16' 0''$, and the lines $c_1 c$ and $d_1 p$ are drawn parallel with Sr, locating the points c and p on the line SR. Now, Sf_1 is laid off $3' 0''$ to the left of S, and a line drawn through f_1 parallel with Sr locates z on the line RS prolonged. A line from z parallel with SL marks the side of the house at fg; hg is perpendicular to and ef is parallel with AB.

12. Now, this is all in simple projection where each line can be scaled for its actual length, but if the triangle itself is put in perspective, as was done in Fig. 7, these measurements and their relative positions can still be maintained by carefully considering the changed conditions.

In Fig. 12, the dotted outline shows the 45° triangle tipped up so that it is foreshortened, or in perspective. The side LR in this case remains unchanged, and points L, r, C, l, and R retain their relative positions. AB is drawn through S parallel with LR. Now, if $Sa_1 = 17' 0''$ and $a_1 b_1 = 15' 0''$ are laid off on AB precisely as in Fig. 11, their equivalent can be fixed on SL by drawing lines from them toward l until these lines intersect with SL at e and h. In Fig. 11, $a_1 e$ and $b_1 h$ were drawn parallel with Sl. But as parallel lines vanish toward the same point in perspective, $a_1 e$ and $b_1 h$ will vanish toward l in Fig. 12, as they are parallel with Sl.

In the same manner, Sc_1 and Sd_1 can be set off on AB to the right of S, each equal to $16' 0''$, and lines from c_1 and d_1 drawn toward r will indicate the perspective equivalent of these distances on SR at c and p, as shown. Sf_1 is set off from S $3' 0''$, and rf_1 is drawn until it intersects RS prolonged at z. A line, therefore, from z toward L will show the projection of the bay window fg in perspective. The projection of cb can be similarly shown by laying off $Se_1 = 6' 0''$ to the right of S, and drawing a line from l through e_1 until it intersects SL prolonged below AB. A line from this point toward R will then locate the side ba. The line of the veranda jkt can similarly be determined by laying off its width $9' 0''$ from S to m and drawing rn through m until it intersects with RS prolonged below AB. Lk is then drawn through the point n until it meets the 45° line Ck, and the return from k is drawn toward R until it intersects cb prolonged at t. The point o_1 is $15' 0''$ to the right of S, as o in Fig. 11 is $15' 0''$ from the line SR. A line drawn from l through o_1, Fig. 12, until it meets LS prolonged marks at p, the point from which the side oq can be drawn toward R.

13. It should be carefully noted that the measuring points l and r are used exclusively to obtain equivalent dimensions on the lines SL and SR, and that all dimensions are first laid off on SL and SR before they are carried to some other line. Also, when the dimensions are to the right, that is, on the line SR, the measuring point used is r, and when the dimensions are to the left, on the line SL, the measuring lines are toward l. This is true whether the measurement is on SL or SR above AB, or on one of these lines prolonged below AB.

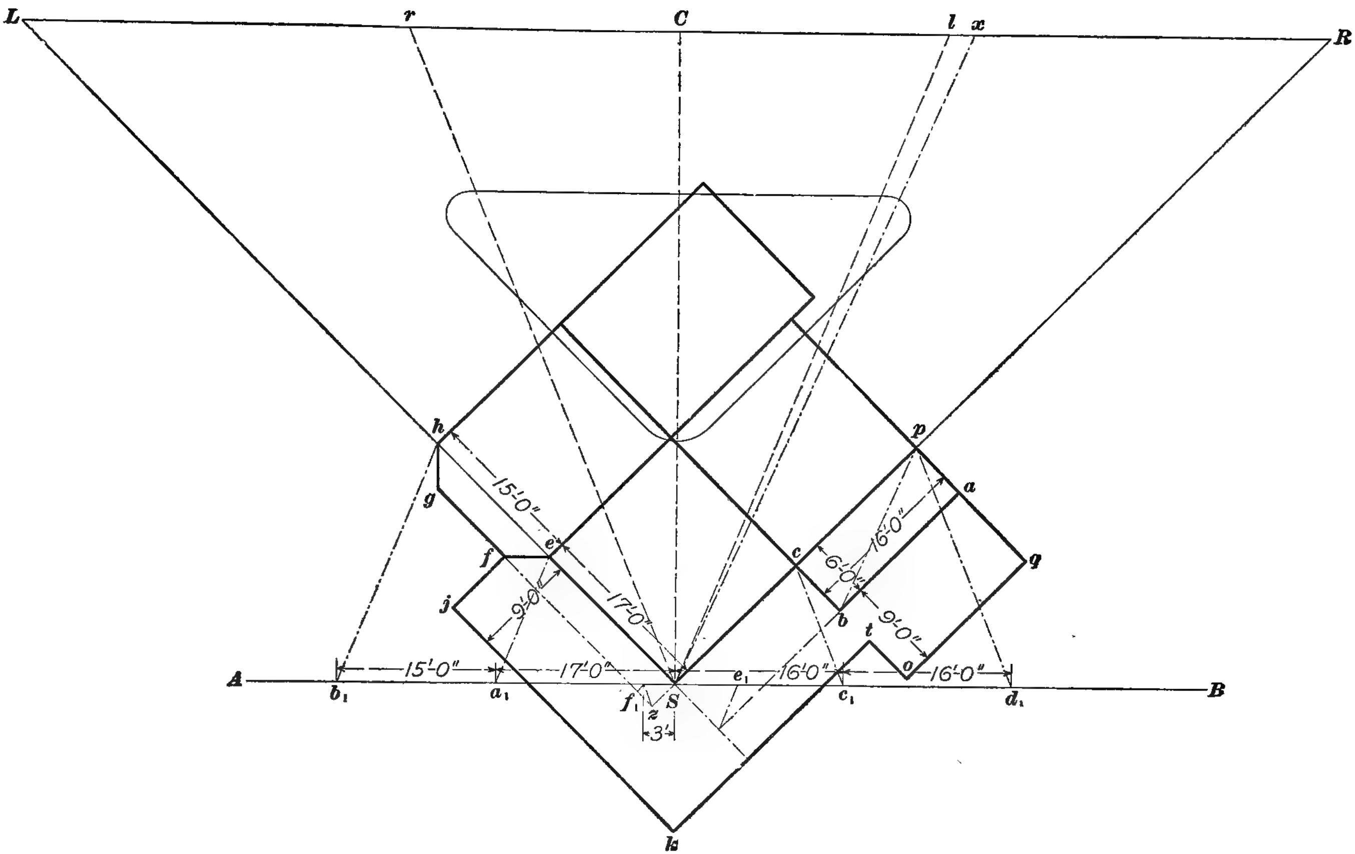

L
r
C
l
x
R
h
g
f
e
j
15'-0"
17'-0"
9'-0"
p
a
c
b
q
t
o
6'-0"
16'-0"
9'-0"
A
b₁
a₁
f₁
z
S
3'
e₁
c₁
d₁
B
15'-0"
17'-0"
16'-0"
16'-0"
k

Fig. 11

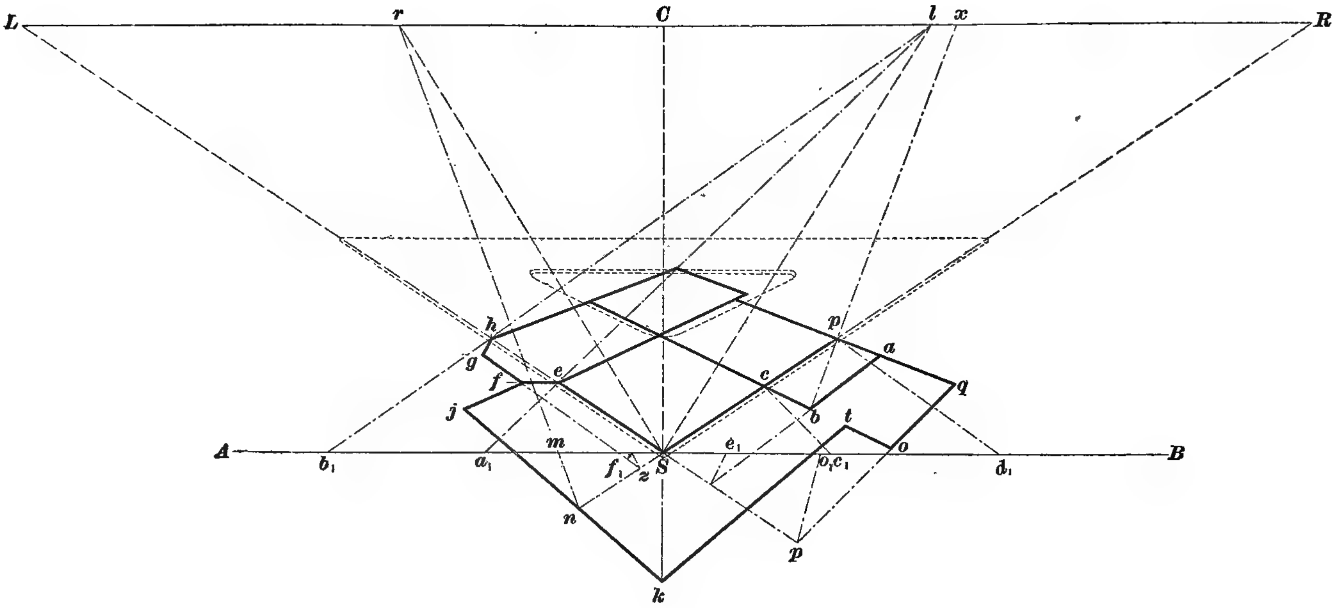


FIG. 12

Now, it has been pointed out that lines parallel with the horizon are parallel in perspective; therefore, fe will be parallel with LR in Fig. 12 as it was in Fig. 11. Also, lines perpendicular to the horizon vanish at C; therefore, gh in Fig. 12 will vanish at C, as shown. Thus, the position of the vanishing point of any line in Fig. 12 can be found by drawing through S, Fig. 11, a line parallel with the desired line, and noting where this parallel line intersects LR. For example, suppose it were desired to locate the vanishing point of the diagonal line bp in Fig. 12. It would be necessary only to draw through S, Fig. 11, a line parallel with bp intersecting LR, as at x; x would then be the vanishing point of bp. Now, if x is located on LR, Fig. 12, the line bp will vanish at that point, as shown by the dotted line. From this it will be seen that the drawing of a plan in perspective is quite as simple as the drawing of it in simple projection, and with the plan once drawn out, the perspective of the elevations may be constructed over the plan by projecting all horizontal lines to their proper vanishing points.

NOTE.—For convenience of reference, all vanishing points will hereafter be designated by the letter V qualified by another letter to indicate its position; as, V^L, V^C, and V^R indicating the vanishing points of lines inclined toward the left or right and perpendicular to the picture plane.

PROBLEMS

EXERCISE I

14. Each problem here given is to be drawn on a sheet 9″ × 12″, outside measurement, or 8″ × 11″ inside the border line. Larger sheets may be necessary to lay out the constructions, but the finished drawings should be only 9″ × 12″.

PROBLEM 1. Exercise I.—Draw a 45° triangle such as shown in Fig. 7 in perspective as follows: V^L and V^R are to be 15 inches apart with the measuring points l and r located according to the proportions given in Art. **19;** corner C of the triangle is to be 3 inches below the horizon and 1 inch to the right of V^C. The triangle is to be actually 4 inches long on the short sides, which are at 45° with the picture plane, but the measuring points must be used to determine the perspective dimensions. The material of the triangle is to be $\frac{1}{8}$ inch thick, and the distance from the outer lines to inner opening should be about $\frac{3}{4}$ inch. Scale full size.

PROBLEM 2. Exercise I.—Make another drawing of the triangle in perspective and place it so the corner C is $3\frac{1}{2}$ inches below the horizon and 1 inch to the left of V^C, and the side $A\,B$ at an angle of 45° with the picture plane.

PROBLEM 3. Exercise I.—Draw in 45° perspective on a scale of $\frac{1}{4}$ inch to the foot, the plan shown in Fig. 13. The corner a is to be in contact with the measuring line 16 feet below the horizon and 4 feet to the left of V^C, and the vanishing points 15 inches apart. The dotted lines indicating the projection of the plans of roof and dormer windows, Fig. 18, should be included. The method of vanishing lines and laying off measurements will be similar to Figs. 10 and 12, where examples of perspective plans are shown.

After completing these three problems, letter the sheets as in the previous Sections, and mail them *flat* to the Schools.

SUBDIVISION OF VERTICAL LINES

15. The subdivision of the vertical elements so as to represent them in perspective, drawn to scale, is a very simple matter, as the direct proportion between vertical heights can be determined at any desired point by drawing lines toward the vanishing points. In Fig. 14 (*a*) is shown an ordinary 12-inch scale; one view *a b* is near the eye, while the other view *c d* is somewhat more distant. Vanishing lines drawn from the points of subdivision on *a b* toward V^R

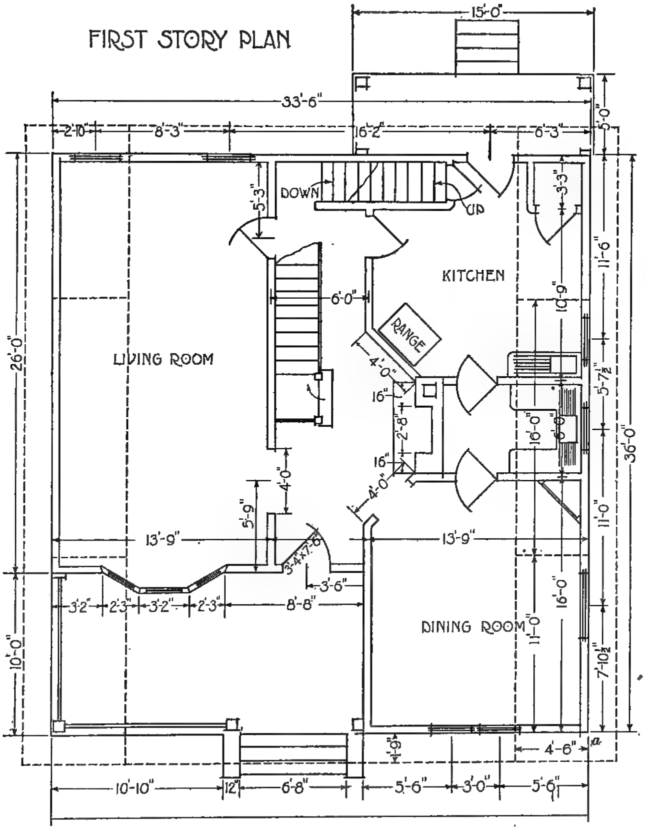
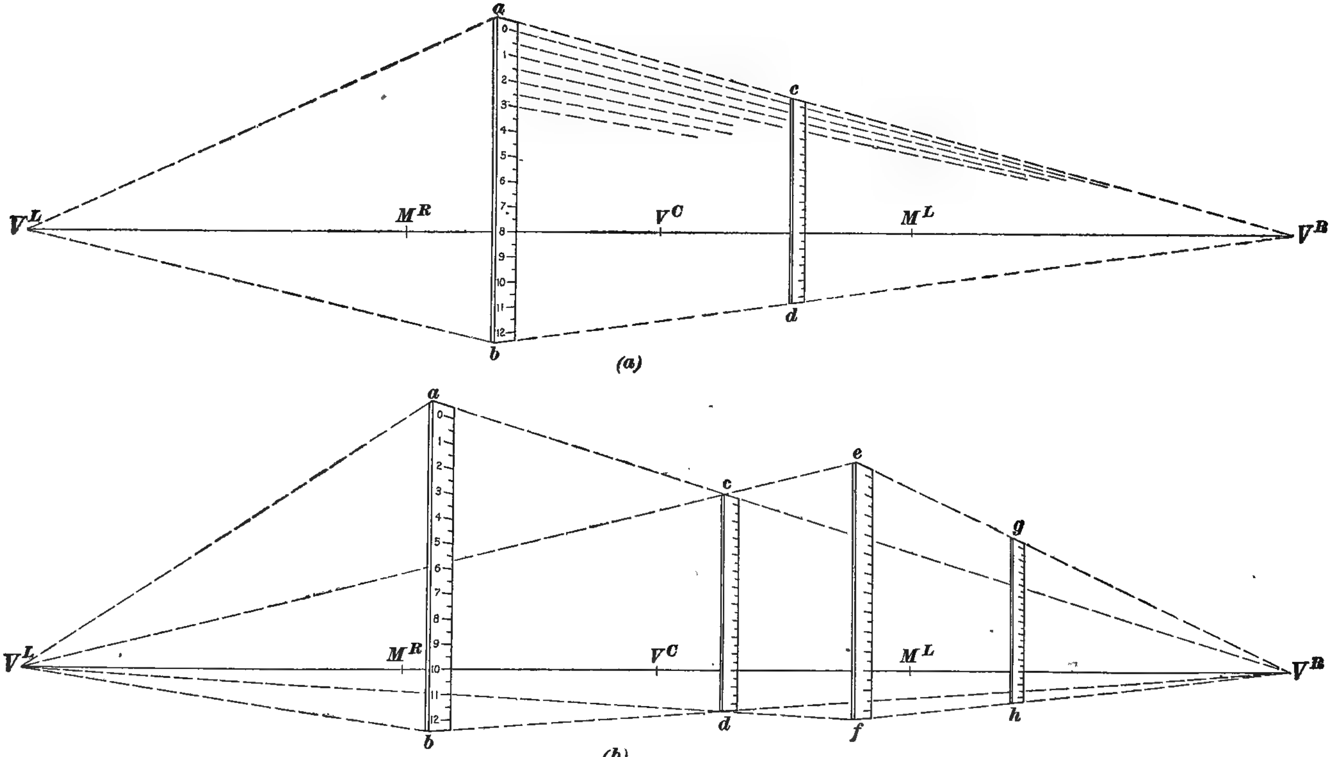


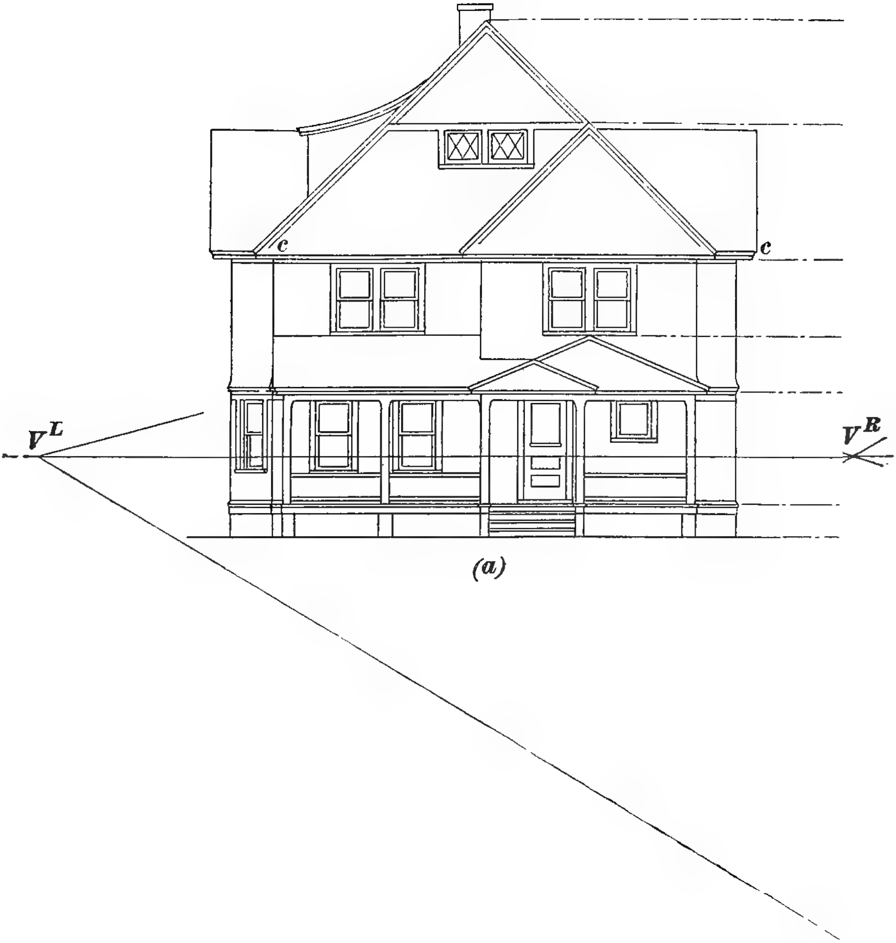
Fig. 13



(a)

(b)

FIG. 14



(a)

establish the points of subdivision on the more distant view *c d*; and although from this drawing there is no direct method of determining how far *c d* is away from *a b*, it is evident that the direct proportions of the subdivisions can be found for any distance.

Now, in Fig. 14 (*b*), this point is carried further. The 12-inch scale is shown at *a b*. Lines drawn from it toward V^R determine the perspective length of that scale *c d*, while lines drawn from V^L through points *c* and *d* determine the size of the scale at *e f*, and lines drawn from *e* and *f* toward V^R again determine the view at *g h*. It is evident that drawing lines from *a b* directly to V^R will not give the proportions of *g h*, because the view *g h* is not on the line $b\ V^R$, and the proportion must therefore be projected from *a b* to *c d*, then back from *c d* to *e f*, and then from *e f* to *g h*. This is particularly important in locating details on perspective views of houses or other objects.

16. In Fig. 15 (*a*) is shown the elevation of a house, while a portion of the perspective plan similar to that in Fig. 12 is shown at (*b*), and the perspective elevation is drawn at (*c*). The principal corners of the house shown in the plan (*b*) are carried up and expressed in the perspective elevation by vertical lines, and the lengths of these vertical lines in the perspective elevation (*c*) are determined from the elevation (*a*). For instance, in the plan (*b*), the side of the house *s c* is carried up and exists in the elevation somewhere between the lines $s\ a_1$ and $c\ a_2$. The vertical limitations of these lines are determined by projecting from the elevation (*a*) horizontal lines to mark the various heights on the measuring line $s\ s_1$. The point of the gable in the elevation (*a*) is expressed on the measuring line $s\ s_1$ at a_1, and a line drawn from here to V^R intersects the line $c\ a_2$ at a_2, establishing the perspective point of the gable at a_2. The eaves of the roof shown at *c* in the elevation (*a*) are measured off on the line $s\ s_1$ at c_1. The measuring line $s\ s_1$ coinciding with the corner of the house makes it unnecessary to project the distance to some other portion of the elevation, as it can be laid off in full scale. The height of this eave line is carried across the front of the building from c_1 to c_2 in the elevation (c), and then on a line drawn from V^L through c_2 is carried to c_3, and from c_3 on a line drawn toward V^R to c_4 in precisely the same manner that measurements were projected from the scale in Fig. 14. The distance the eave line is carried from c_1 to c_2 is determined by lines projected from s and c in the plan (b), and from c_2 to c_3 is limited by lines drawn from c and b in the plan (b), while lines drawn from b and a determine the limitations of the line from c_3 to c_4.

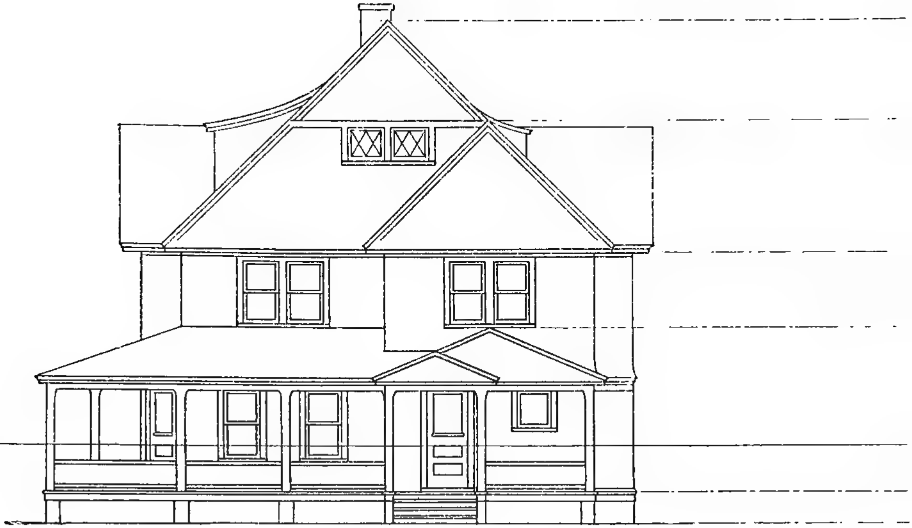
Only one elevation of the house is here shown, but the other elevation can be equally well drawn by projecting its vertical distances to the measuring line $s s_1$ and its horizontal distances from the other side of the plan, as shown in Fig. 16.

Although the two elevations are in this case drawn each side of the perspective elevation, and their vertical measurements projected to the measuring line $s x$, in general practice this is not necessary, as the vertical distances can be scaled from the elevations on other pieces of paper and transferred to the measuring line $s x$, so that their proportions may be secured in their proper places. Here, then, are given the means of locating the size, appearance, and proportion of any surface in any direction by securing a perspective plan of same, as in Fig. 12, and building the elevations over the plans, as in Figs. 15 and 16.

EXERCISE II

PROBLEM 4. Exercise II.—Make an outline 45° perspective, scale $\frac{1}{4}$ inch to the foot, of the building shown in Fig. 17. First, draw the perspective plan 5 inches below the horizon, the corner a $1\frac{1}{4}$ inches to the left of V^C, and the ground line in the elevation 6 feet below the horizon. The sides of the building are to be 45° with the picture plane.

PROBLEM 5. Exercise II.—Make another drawing of the building shown in Fig. 17, in perspective, and give a detailed description of the point nearest the eye from which measurements were taken, the position of this point



Front Elevation

5 B

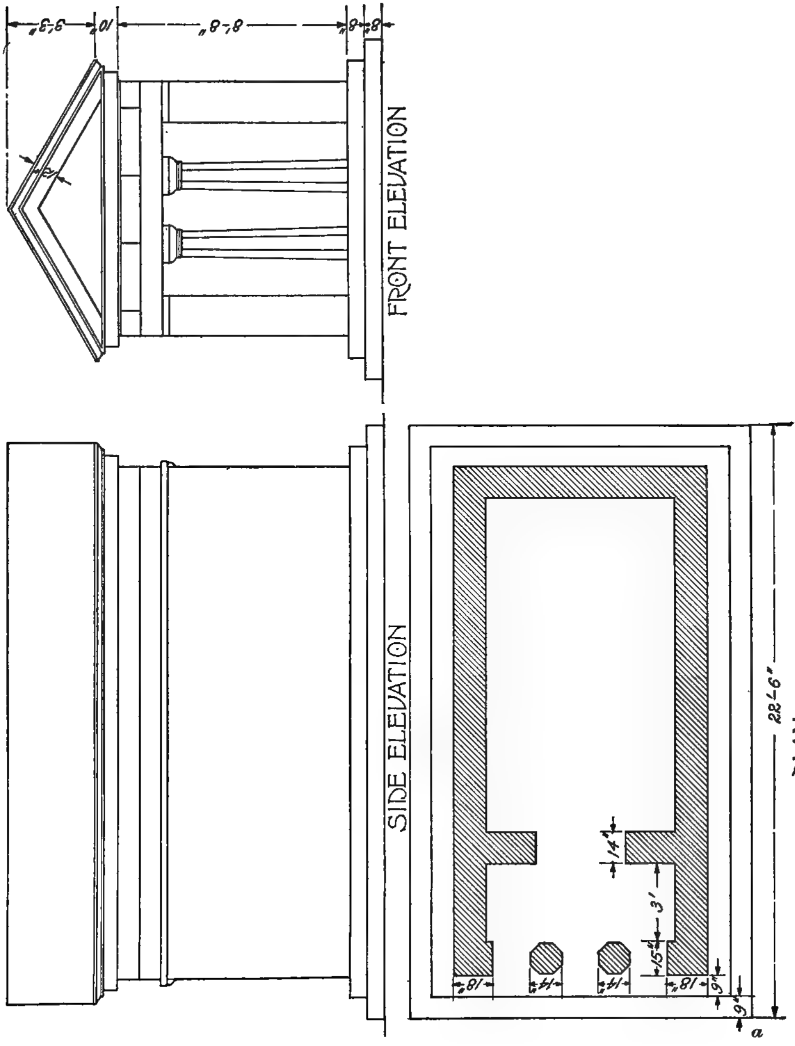

9'3"
10"
8'8"
8"
8"
12"
FRONT ELEVATION
SIDE ELEVATION
PLAN
28'-6"
18"
14"
14"
18"
9"
9"
15"
3'
14"
a

Fig. 17

relative to the horizon and to V^C, the distance between the vanishing points, etc.

PROBLEM 6. Exercise II.—Make a perspective drawing of the elevations shown in Fig. 18 (*a*) and (*b*), using therefor the plan previously drawn in Problem 3, Exercise I, the horizon in this problem to be 5 feet above the ground line.

17. When the station point is assumed exactly half way between V^L and V^R, the sides of any rectangular building to be drawn in perspective will be at an angle of 45° with the picture plane, and the drawing is said to be made in 45° perspective. This is shown in Fig. 11, where the sides of the house coincide with the sides of the triangle that makes a 45° angle with the picture plane *L R*.

If the station point is not equidistant from V^L and V^R, as in Fig. 19, the center of vision, measuring points, and vanishing points are irregularly spaced, and much more work is required to attain the same results. In Fig. 19, the plan is laid out in perspective on a 30° × 60° triangle, as it was, in Fig. 12, on a 45° triangle. Here, *V* is not midway between the principal vanishing points, and the center of vision *C* does not coincide with *V*, thus making one extra point to consider.

There are many advantages in working all drawings possible in 45° perspective. The center of the picture *C* and *V*, the vanishing point of 45° coincide, the principal lines from *S* to V^L and V^R make an angle of 45° with the picture plane, and it is much simpler to lay out a perspective with the object at 45° than at any other angle. It is usually best to arrange the station point at 45° and to set the object to the right or left of the center of vision in order to expose either side more or less to view. The station point in a 45° perspective is located at its maximum distance from the picture plane, which is always a decided advantage, and the distance from the station point to the picture plane is equal to one-half the distance between the principal vanishing points (see rule III, Art. **7**). Therefore, as *S* is equidistant from

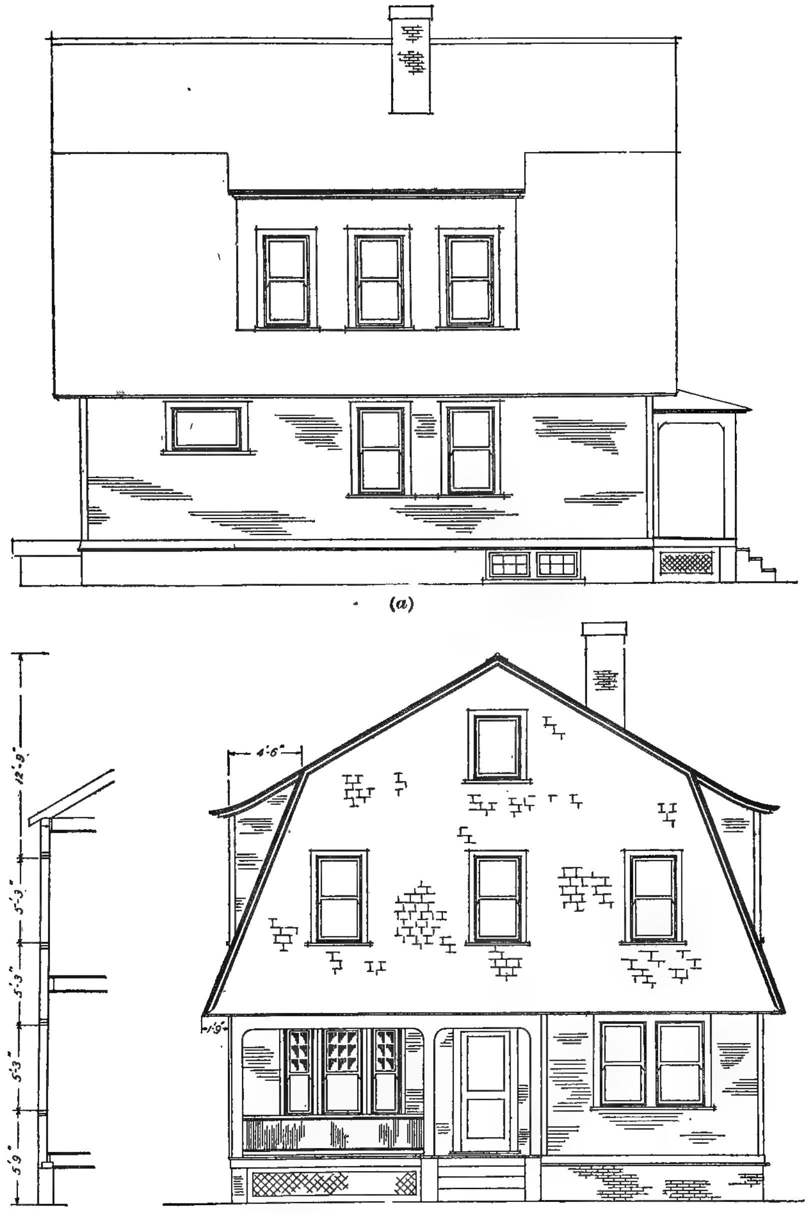


FIG. 18

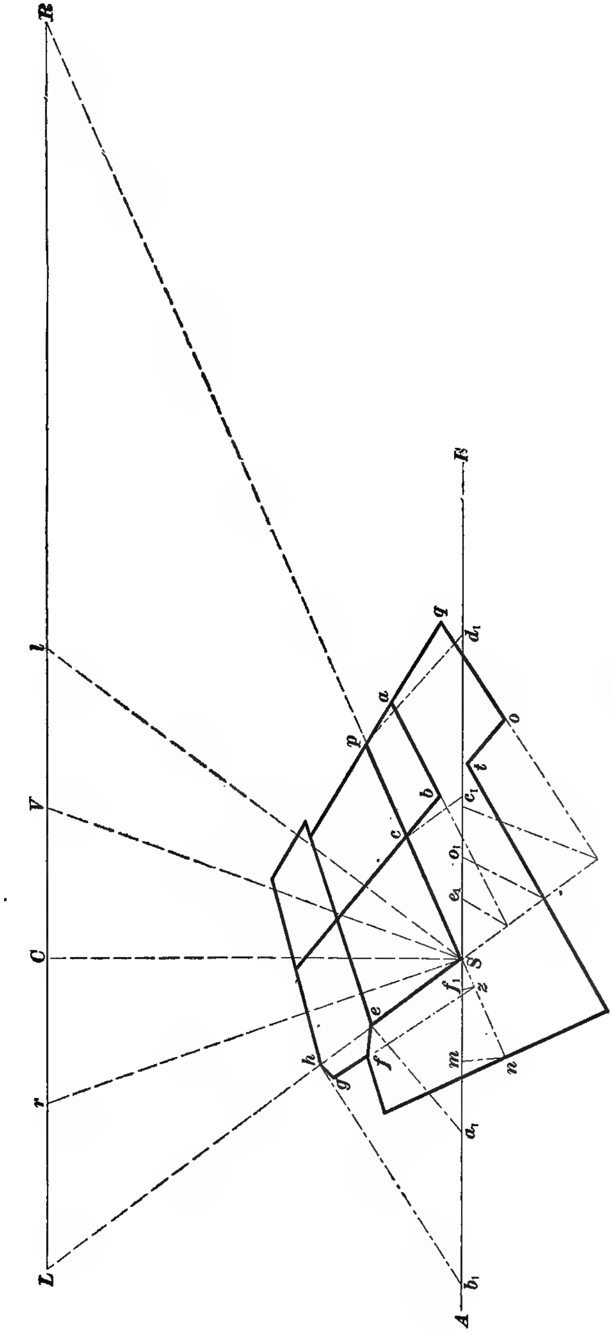


FIG. 19

V^L and V^R, it follows that M^L and M^R are equidistant each side of V^C.

18. Application of the Octagon.—Another point of simplicity in this arrangement is found in the ease with which the various measuring points and vanishing points may be located, it not being necessary to lay out these details on a large sheet, as will be seen by referring to Fig. 20,

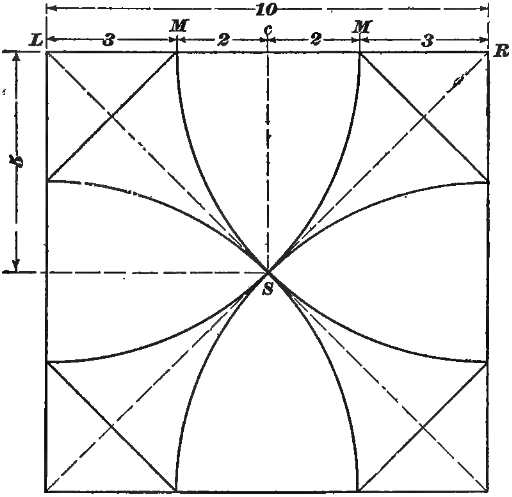


FIG. 20

which is simply a diagram of one of the methods of laying out an octagon geometrically. From the four corners of a square, a distance is laid off on each side equal to one-half the diagonal, thus locating points from which lines may be drawn to cut off the corners of the square to reduce it to an octagon. The section of the square *L S R* will be found to correspond exactly with the horizon line and station point (Fig. 11), and the distances laid off on the side *L R* will be found to correspond exactly with the distances laid off for the measuring points on the horizon.

19. Standard Proportions.—Therefore, it may be assumed that, for all practical purposes, in laying out a perspective at 45°, the distance from the horizon to the station point is equal to one-half the length of the horizon; the distance from the center of vision to the measuring points is one-fifth the horizon; and the distance from the measuring points to the nearest vanishing point is three-tenths the horizon. In other words, if the distance from V^L to V^R is divided into ten equal parts, then from S to V^C will be five parts, from V^C to M^R will be two parts, and from M^R or M^L to V^L or V^R will be three parts.

DIVISION OF LINES

20. The division of vertical lines in perspective presents no difficulty, because the line is parallel with the picture plane and may be divided into two, three, or four equal parts, or into other relatively proportional parts, by direct measurements; but the division of horizontal lines that recede from the eye, except by projection from the perspective plan, is more difficult, as the subdivision most distant is shorter than the portion nearer the eye, and it is not always clear how much difference there should be.

Two methods to determine these relative proportions have been adopted—one known as the *method of diagonals*, and the other as the *method of triangles*.

21. The **method of diagonals** is based on certain geometrical properties of the parallelogram, and can be considered in five cases.

22. **Case I.**—The diagonals of a parallelogram intersect at the center of the parallelogram, and a line drawn through their point of intersection, parallel with two of its sides, will bisect the other two sides of the parallelogram and also the parallelogram itself. The diagonals $a\,b$ and $c\,d$ of the parallelogram in Fig. 21 intersect at e, and the line fg drawn through their point of intersection e, parallel with the sides $b\,c$ and $a\,d$, bisects the sides $a\,c$ and $b\,d$ and also the parallelogram itself, as shown.

In the parallelograms formed by means of the line fg, the diagonals ag and $d\,f$ intersect at h, and the line $k\,l$ drawn through the point of intersection *h*, parallel with the sides *fg* and *a d*, bisects the sides *a f* and *dg* and also the parallelogram *a d g f*.

By this method of diagonals it is seen that the line *a c* is divided into two equal parts by the line *fg*, whereas the distances *a k* and *k f* are each equal to one-quarter the line *a c*. The subdivision of this line into eighths, sixteenths, etc. can be readily carried out by subdividing the parallelograms formed by the diagonals, as shown.

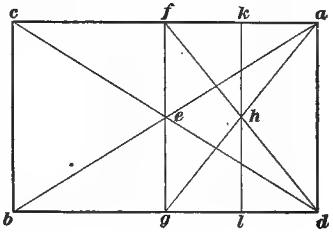


FIG. 21

23. The application of this case to a perspective drawing is shown in Fig. 22, where the side *a b c d* of a building is in the form of a parallelogram. The diagonals *a c* and *b d* intersect at *e*, thus marking the center of this parallelogram, and the line *e f* drawn parallel with the vertical sides must pass through the center of the gable—the height of which is laid off on the corner of the building at *f'*—and by means of a vanishing line drawn from *f'* to the vanishing point V^L it must locate the point of the gable at *f* without further consideration of the plan.

In the same manner, the position of the point of the tower *g* can be located by means of the diagonals *g' h'* and *k' l'* in the plan. These diagonals intersect at *o*, showing directly the position of the apex at the point of the tower roof. The location of the apex of the more distant tower, shown at *g''*, is found in the same way, the diagonals not being drawn in the ground plan, as the perspective ground plan does not extend to that part of the building; but a plan is drawn at the top of the tower itself, as shown, and a vertical line erected at the intersection of the diagonals.

24. **Case II.**—If through the intersection of the diagonals of a parallelogram a line is drawn parallel with two of the sides, a single line will thereafter be sufficient to establish any equal subdivisions of the other two sides, as shown in

Fig. 23, where the line *a b* is drawn through the intersection of the diagonals of the parallelogram at *c*, and the diagonal *d e*, intersecting the line *b c* at *f*, bisects the line *b c* and also the smaller parallelogram *e g d h*. A line drawn through *f* parallel with *e g* will give precisely the same subdivisions in the parallelogram, Fig. 23, that were obtained in Fig. 21, but with fewer construction lines.

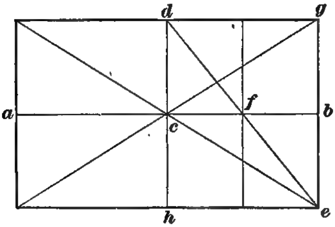


FIG. 23

25. The application of this case in Fig. 22 is shown in the subdivision of the rectangular side *a b c d*, where the line *k l* is drawn through the point of intersection of the diagonals at *e* toward the vanishing point at V^L. A diagonal drawn from *d* to *h* will then bisect the line *e k* at *i*, and a diagonal drawn from *d* to *j* will bisect the line *k i* at *i'*, thus subdividing the rectangle *a b c d* into two equal parts by the vertical line through *e*, into four equal parts, if desired, by vertical lines through *i*, and into eight equal parts by vertical lines through *i'*.

26. Case III.—If a line is drawn from a corner of a parallelogram through the center of one of the opposite sides of the parallelogram, and continued until it intersects with the other opposite side prolonged, the length of that side may thereby be doubled and likewise the parallelogram itself.

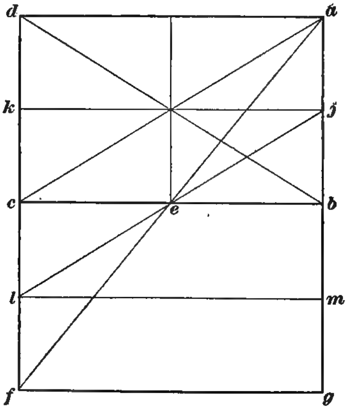


FIG. 24

In Fig. 24 is shown a parallelogram *a b c d*, from the corner *a* of which is drawn a line *a f* passing through the

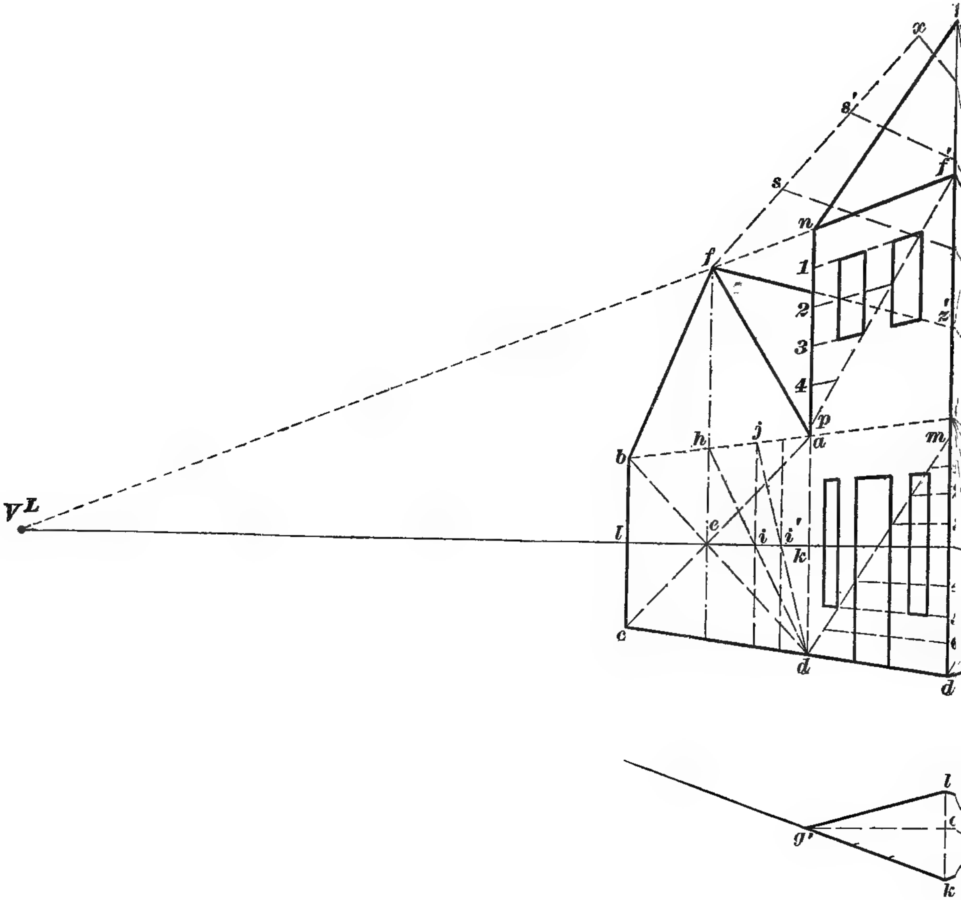
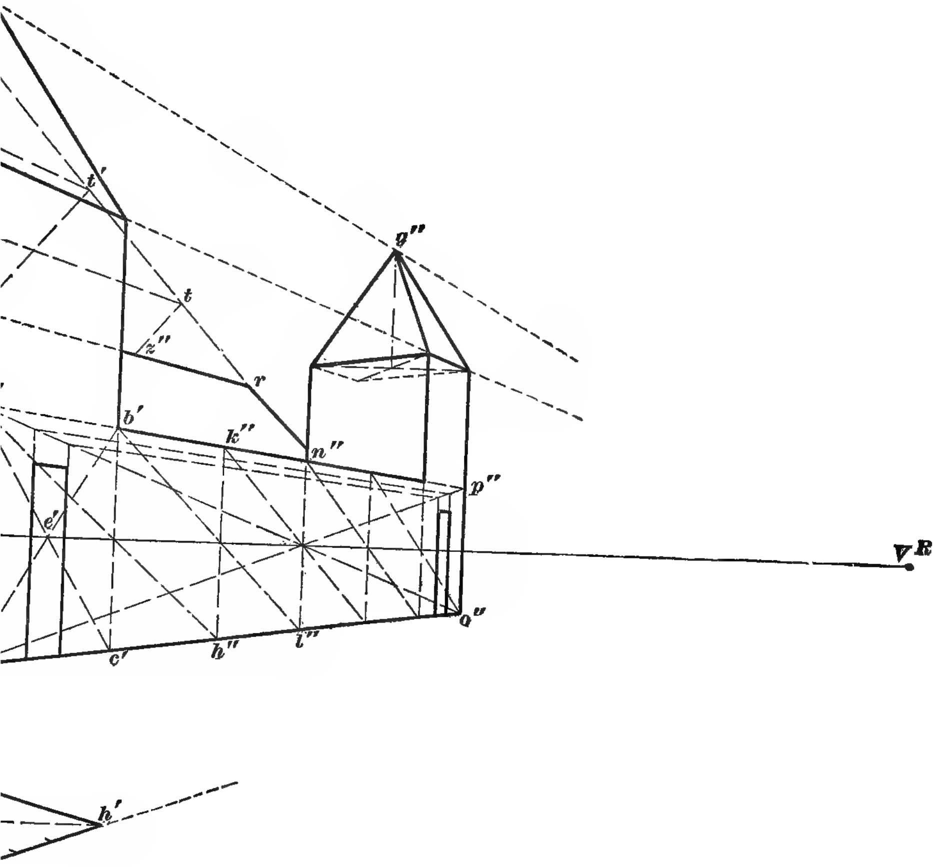


FIG. 2



§ 5

center e of the opposite side cb and intersecting the opposite side dc prolonged at f. The distance cf is therefore equal to cd, and the parallelogram constructed at $cfgb$ is equal to the parallelogram $abcd$. If, now, the line jk is drawn through the intersection of the diagonals of the parallelogram $abcd$, and from j a line is drawn through e, the center of bc, thereby locating the point l on the line dc prolonged, the distance cl is equal to the distance ck, and the parallelogram $clmb$ is equal to the parallelogram $kcbj$, which is one-half the parallelogram $abcd$. In this manner the original parallelogram has been increased one-half in the latter case, and doubled in the first case.

27. The application of Case III in Fig. 22 is shown on the right side of the building where, at $a'b'c'd'$, is given a parallelogram forming the side of the tower; the diagonals $d'b'$ and $a'c'$ intersect at e' and mark the center of the parallelogram, through which a line is drawn to the vanishing point V^R.

If a line is drawn from a' through the center of the side $b'c'$ and continued until it intersects with $d'c'$ prolonged at h'', another rectangle $b'c'h''k''$ equal in every respect to the parallelogram $a'b'c'd'$ can be constructed. And, again, drawing a line from b' through the center of the side $k''h''$ until it intersects with the line $c'h''$ prolonged to l'', another parallelogram $k''h''l''n''$ can be constructed; and so on to the completion of that side of the building, the entire side consisting of six parallelograms, each equal to $a'b'c'd'$.

28. Case IV.—If the side of a parallelogram is divided, in any manner, near one end, equal subdivisions may be laid off near the other end by means of the diagonals.

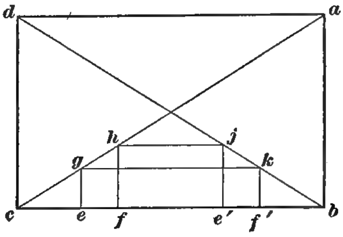


FIG. 25

In the parallelogram $abcd$, Fig. 25, the diagonals ac and db are given, while at e and f are two points on the side cb

near the end c. If the lines eg and fh are drawn parallel with the side cd until they intersect with the diagonal ac, and from these points of intersection the lines hj and gk are drawn until they intersect with the diagonal db, lines drawn from the points j and k parallel with the side ab will intersect the line bc at e' and f', so that the distances bf' and $e'f'$ will be equal to the distances ce and ef.

29. The application of Case IV in Fig. 22 is shown in the location of the door openings in the two towers, where the side lines of the door of the nearest tower are continued upwards until they intersect with the diagonal $a'o''$ of the parallelogram $a'p''o''d'$, and from these points of intersection, vanishing lines are drawn toward V^R until they intersect with the diagonal $p''d'$, and vertical lines drawn from these latter points of intersection will mark the width of the door in the more distant tower, as shown.

30. **Case V.**—If one side of a parallelogram is subdivided into parts of any relative proportion, either of the adjacent sides may be divided in the same proportion by means of one of the diagonals, and the relative positions of these proportional parts may be in the same or the reversed order, according to which of the diagonals is used.

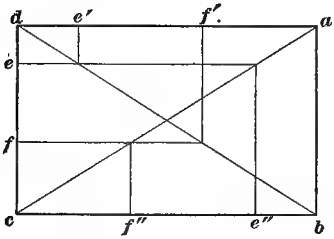


FIG. 26

In Fig. 26 is given a parallelogram $abcd$, the end of which is divided at e and f. If lines are drawn from e and f parallel with the side ad until they intersect with the diagonal bd, and from these points of intersection lines are drawn parallel with the side dc, these lines will subdivide the side ad at e' and f' so that the proportions of de', $e'f'$, and $f'a$ will be the same as the proportions of de, ef, and fc. Or, if from e and f lines are drawn parallel with ad until they intersect with the diagonal ac, and from these points of intersection lines are drawn parallel with the side dc and intersecting the side *b c* at e'' and f'', the subdivisions of the line *b c* will be proportional to the subdivisions of the line *c d*, but in the reversed order from the subdivisions, as laid out on the other diagonal for the line *a d*.

31. The application of this case to Fig. 22 is shown in the location of the windows on each side of the door opening in the nearer tower. The distance *m d′* on the corner of the tower is laid off equal to the scale width of the tower in elevation, and at *m–1*, *m–2*, *m–3*, etc. are laid off the scale measurements of the windows and doors, *m–1* being the scale distance from the corner of the tower to the edge of the window, *1–2* the width of the window, *2–3* the space between the window and the door, *3–4* the width of the door, etc. Lines drawn from *1*, *2*, *3*, *4*, etc. toward the vanishing point V^L intersect the diagonal *m d* at points through which vertical lines may be drawn to establish the width of the windows and door.

32. It is evident from this that a definite length of a given parallelogram in the perspective drawing is unnecessary, as the line *a′ d′* can be laid off in any place and at any convenient length, so long as its subdivisions may be carried toward a vanishing point and be intersected by a diagonal.

For instance, on the farther corner of the left-hand side of the tower there are laid off, from *n* to *p*, certain subdivisions corresponding with the width of the windows and the spaces between them in the upper part of the tower. A diagonal then drawn from *p* to *f′* furnishes a line on which the subdivisions between *n* and *p* may be laid off for the windows, by means of vanishing lines drawn from V^L through the subdivisions between *n* and *p* to intersect on *p f′*. The distance *n p* may be laid off arbitrarily, longer or shorter, as here shown, and the subdivisions *n–1*, *n–2*, *n–3*, etc. may be at any convenient scale, so long as the total distance *n p* equals the scale width of the tower in elevation. The line *n f′* is fixed, however, as it represents the width of the tower in perspective, and lines drawn from the vanishing point V^L through the subdivisions of the scale width of the tower *np* will intersect on the diagonal *pf'*, so as to locate the subdivisions across the apparent width of the tower in perspective.

33. In the application of each of these five cases, all lines running to the same vanishing point have been considered as being parallel, whereas all vertical lines actually are parallel, and if this is well borne in mind, difficulty in transferring measurements from scale elevations to perspective surfaces will never be encountered.

34. The Method of Triangles.—In the application of the last case, it will be observed that only one-half of the parallelogram has been used, and though the principle involved is that of the diagonal of a parallelogram the problem resolves itself into the use of a triangle.

Therefore, Case V might be stated definitely as follows: If one side of a triangle, as *dc*, Fig. 26, is divided into any relative proportions, the adjacent side *da* may be divided into similar proportions by lines drawn parallel with the two sides and meeting on the third side *ac*.

35. The last application of this case also gives rise to a proposition, that if from one end of any given line in a perspective drawing another line is set up parallel with the picture plane, any subdivisions laid off on the lines so set up may be transferred, proportionately, to the given line on which it is set up by means of a third line connecting the last point taken on the set-up line and the other end of the line.

The application of this principle in Fig. 22 is shown in the location of the lightning rods along the roof of the building at *fr*, where from *f*, a line *fx* is erected arbitrarily and divided into three equal parts at *s* and *s'*, and from *x* a line is drawn to *r*, completing the triangle *fxr*. This triangle may be of any size or proportion, but the side *fr* must always be the same. Lines then drawn from *s* and *s'* to the vanishing point V^R (V^R being the vanishing point of the given line *fr*) will intersect the line *xr* at points *t'* and *t*, from which points of intersection lines drawn parallel with *f x* will intersect the given line *f r* at points *z'* and *z''*, which mark the location of the lightning rods along the ridge.

This same principle may be used at any time to locate any number of equal or proportional subdivisions in any perspective line whatever, thus eliminating from the perspective plan much detail that would otherwise be required.

INCLINED PLANES

36. Besides the vertical and horizontal planes that are parallel with the ground and with the picture plane, it is sometimes necessary to find the vanishing points of lines that form the boundaries of inclined planes, such as the slopes of roofs, etc.

In Fig. 27 is shown a bird's-eye view of a simple four-gabled building. The lines parallel with the sides of the building vanish at V^R and V^L, as these lines are at 45° with the picture plane and parallel with the ground, but lines parallel with the roof slopes are inclined at an angle of 45°, and the vanishing points of these lines will be somewhere above or below the regular vanishing points V^R and V^L. If diagonals are drawn in the end rectangle *a b c d*, the center point *o* can be found, and a perpendicular can be erected that will mark the center line *o e* of the gable *a e b*. The height of *e* can be laid off at any point on the scale line, projected around and located on the line *o e*. The same can be done with the points of each of the other four gables, but when lines *a e* and *m n* are drawn, it will be found that they intersect at V^M, while *g l* and *r p* prolonged intersect at V^N. In the same manner, it will be found that *e b* and *l h* intersect with the vertical lines through V^L and V^R at points $V^{M'}$ and $V^{N'}$. Therefore, the points V^M and $V^{M'}$ and V^N and $V^{N'}$ are the vanishing points of lines inclined to the right and left at an angle of 45° and upwards, parallel with the roof slopes, and all lines in the roof slopes inclined at the same angle over a plan placed at 45° with the horizon will intersect at these points. It will be observed, however, that the vanishing

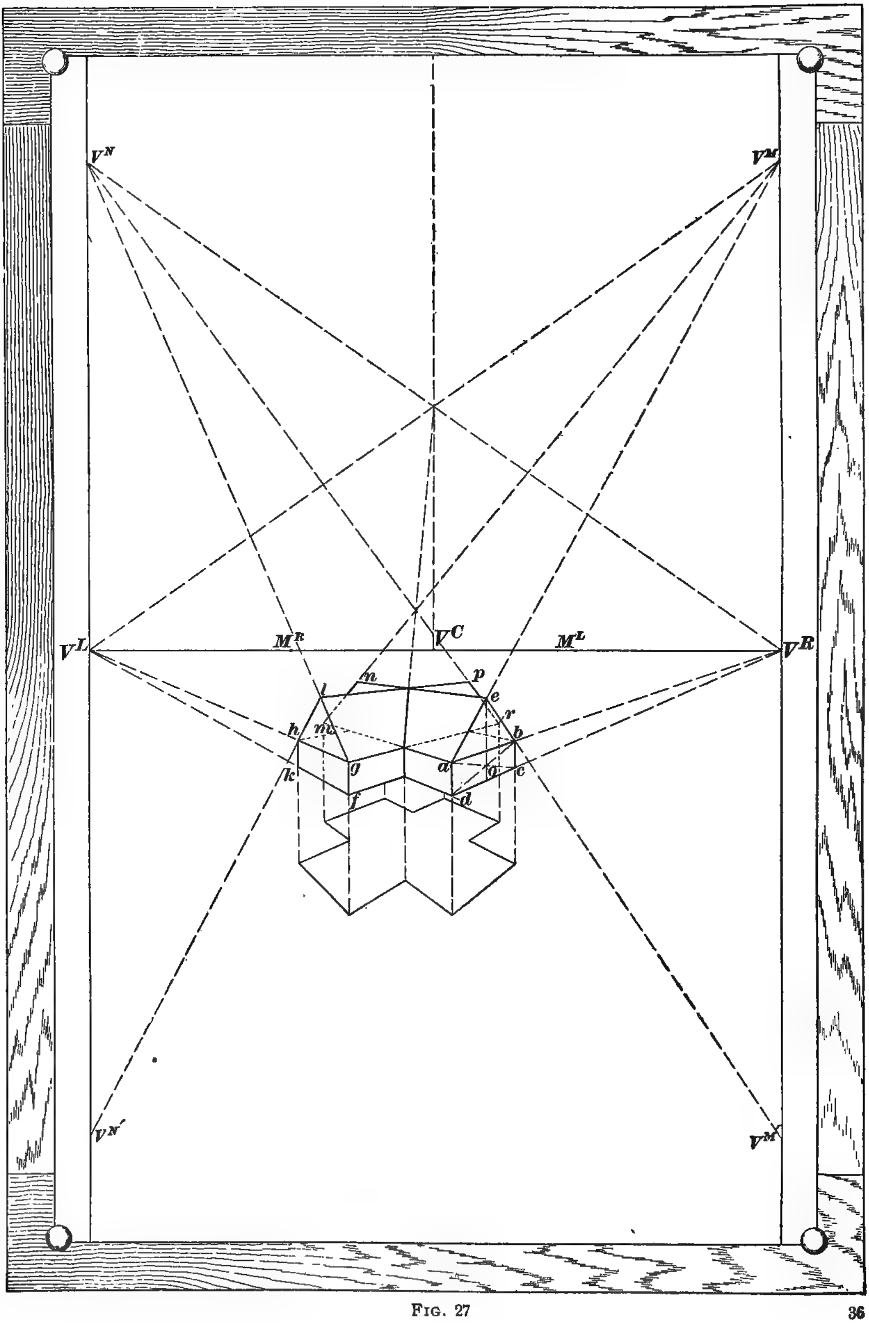


FIG. 27

points of these 45° lines are in line with the points V^L and V^R; therefore, if, in laying out a perspective, vertical lines are drawn through V^L and V^R, on these lines prolonged will be found the intersection of all the vanishing lines inclined upwards or downwards to the right and left and at an angle of 45° with the picture plane. Therefore, instead of laying out the center line of the gable *o e*, it will simply be necessary to project the lines directly from the corners of the front of the building, as from *a* toward V^M and from $V^{M'}$ through *b* to *e*.

37. In Fig. 28 is shown a method of getting these vanishing points quite as simply as the other vanishing points are obtained, so that the points may all be determined before the perspective drawing is commenced. After drawing the horizontal line V^L–V^R, and locating V^C, M^R, and M^L, draw through V^R–V^L vertical lines indefinitely, as shown. From M^R and M^L, draw diagonals with the triangles set at an angle of 30° or 45°, as shown, when the lines of the roof slopes or other lines are inclined at an angle of 30° or 45°. The points V^M, V^N, $V^{M'}$, and $V^{N'}$ on the vertical lines through V^L and V^R are then established as the vanishing points of lines at an angle of 45°, while V^{M^2}, V^{N^2}, V^{M^3}, and V^{N^3}, in a like manner, show the vanishing points of lines inclined at an angle of 30°.

It should be noted that the angle at which these vanishing points are laid off is made at the measuring point, thus showing another useful application of this system. Where the lines from V^L to V^M and V^R to V^N intersect will be found the vanishing point of the line of intersection between the inclined planes, or, in other words, the valley of the roof slope, V^P and $V^{P'}$ being the vanishing points of the intersections of roof slopes at an angle of 45°, while V^Q and $V^{Q'}$ show the vanishing points of lines of intersection of the roof slopes at 30°. These facts should be carefully studied and various sketches made of these and the previous problems, in order that the fundamental principles of perspective drawing may be clearly understood.

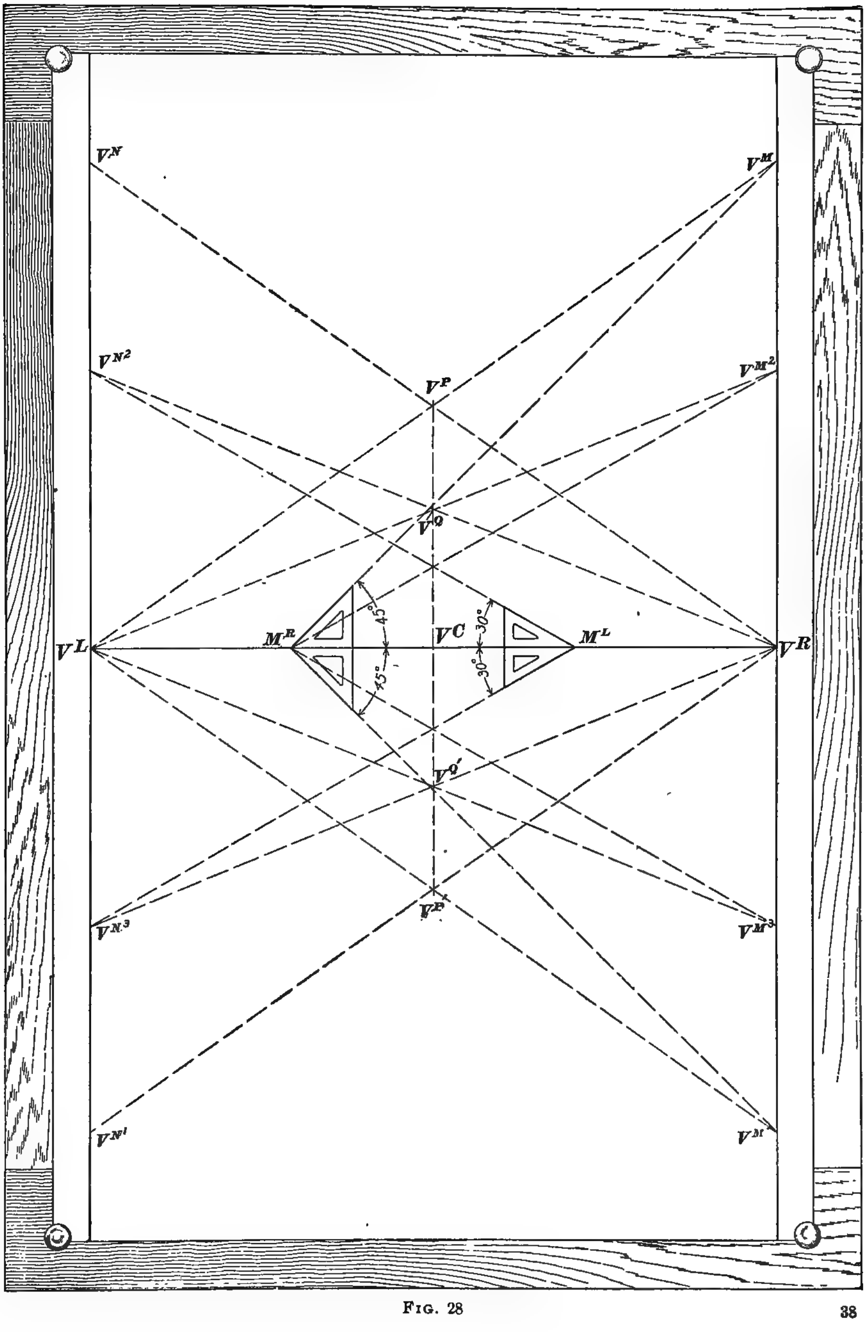


FIG. 28

38. Any part of an object in contact with the picture plane may be laid off to a proportional scale direct (rule I, Art. 7), and if the perspective is to be drawn full size, the details of the object in contact with the picture plane may be laid off to a full-size scale. On the other hand, if it is assumed that the object itself is replaced by a small model on a scale of one-half size or a smaller scale of $\frac{1}{8}$ or $\frac{1}{16}$ inch to the foot (as is usually the case with a house), and that this model is in contact with the picture plane, then the perspective may be considered a full-size drawing of the *model*, and a $\frac{1}{8}$- or $\frac{1}{16}$-inch scale, as the case may demand, may be used for the measurements.

39. In Fig. 29, the horizontal line has been drawn about 5 inches in length, and the principal points have been located thereon, according to the proportions given in Fig. 20. At *a b c*, Fig. 29, a line is drawn at any convenient distance below the horizon, and from *b* toward *a* the length of the side of the house is laid off, while from *b* toward *c* the details of the front of the house are laid off. Lines are first drawn from *b* to V^L and V^R. Lines drawn from the divisions on *b c* toward M^R subdivide the perspective view of the end of the house, and a line drawn from *a* toward M^L limits the perspective length of the side of the house. Thus, the two sides of the house and the details they contain may be located and proportioned.

40. By drawing diagonals through the parallelogram in the elevation forming the end of the house, the vertical center line can be located and thereby the position of the point of the gable can be established. On the line formed by the corner of the house in contact with the line of measures, *a b c* can be measured, at *h*, *d*, and *e*, 21′ 0″, 12′ 0″, and 7′ 6″, the heights of the two slopes of the gable, as shown on the front elevation, and where a line from the highest point *e* toward V^R intersects this vertical center line is located the peak of the gable. V^M and $V^{M'}$ are readily located from M^R by means of a 30° triangle, and the slopes from the peak of the roof toward V^M and $V^{M'}$ can be laid out, and at the same time establish by their intersection with the line from *d* to V^R the points where the lower slope of the roof intersects, thereby obviating the necessity of using the vanishing points of the 60° slope of the roof when these points are so inaccessible.

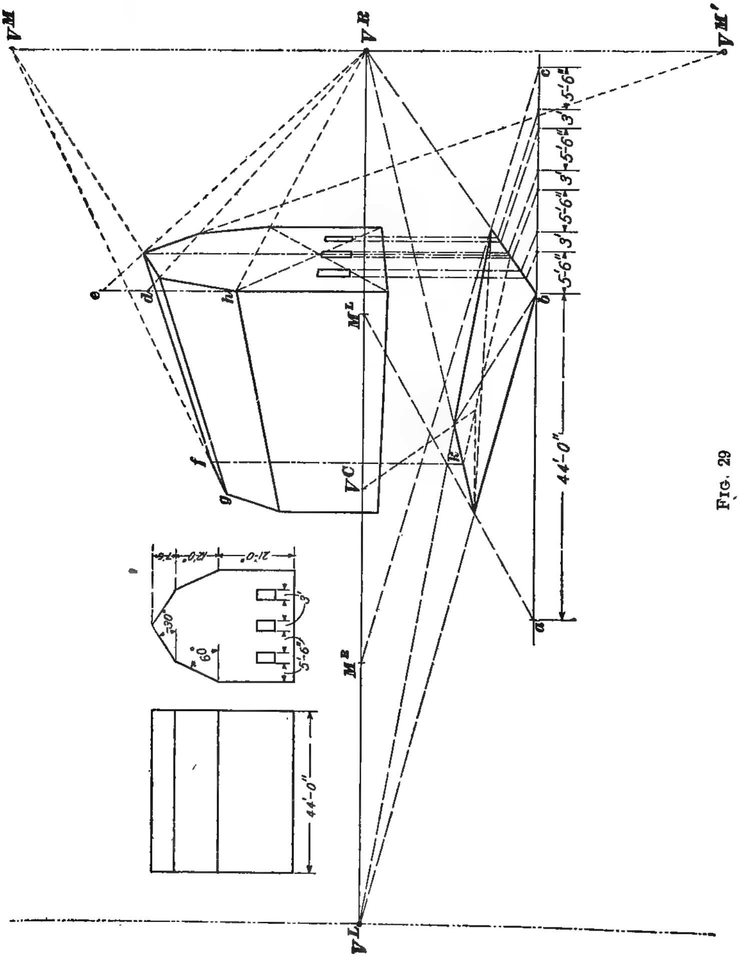


FIG. 29

41. Diagonal lines through the plan locating its center and the line through this center toward V^L locate the center of the gable at *K* on the opposite end of the house, a vertical line from which will intersect with the ridge and mark a point *f* where the 30° slope can be laid off on that end, and the intersection of this, at *g*, with the line drawn toward V^L will locate the points required for the slope on this end.

PARALLEL PERSPECTIVE

42. Difference Between Parallel Perspective and 45° Perspective.—Now will be considered the perspective rendering of objects whose sides, instead of inclining at an angle of 45° with the picture plane are perpendicular to the picture plane; in other words, rectangular objects that are so placed that one side is parallel with the picture plane, and the other side at right angles to it. In 45° perspective, V^L and V^R are equidistant from V^C, and the measuring points M^L and M^R are also symmetrically disposed on each side of the center. In parallel perspective, the same layout of the various points can be assumed, but the main vanishing point will be V^C in the center of the picture, and V^L and V^R will then become the vanishing points of 45°.

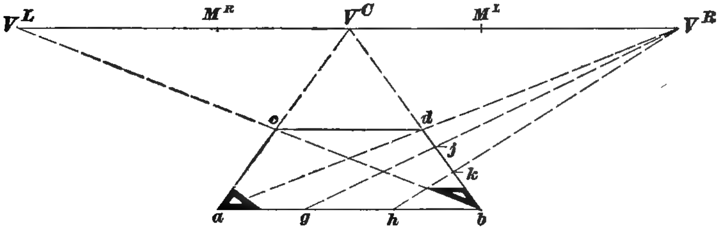


FIG. 30

43. In Fig. 30 is shown a horizontal line V^L–V^R with the several points located as explained in Fig. 20. At *a b d c* is shown the perspective plan of a square. The sides *a b* and *c d* are parallel with the picture plane, and *a c* and *b d* are perpendicular to the picture plane; therefore, the latter vanish at V^C. Thus, the diagonals of the square *a d* and *b c* are at an angle of 45° with *a b* and *c d*, and consequently at the same angle with the picture plane. These diagonals must then vanish toward V^L and V^R. Then, *a b* is equal to *b d*, and any distance laid down on *a b* can be transferred to *b d* or *a c* by lines drawn toward V^R or V^L. Thus, *j k* on *b d* is the perspective representation of the distance *g h* on *a b*.

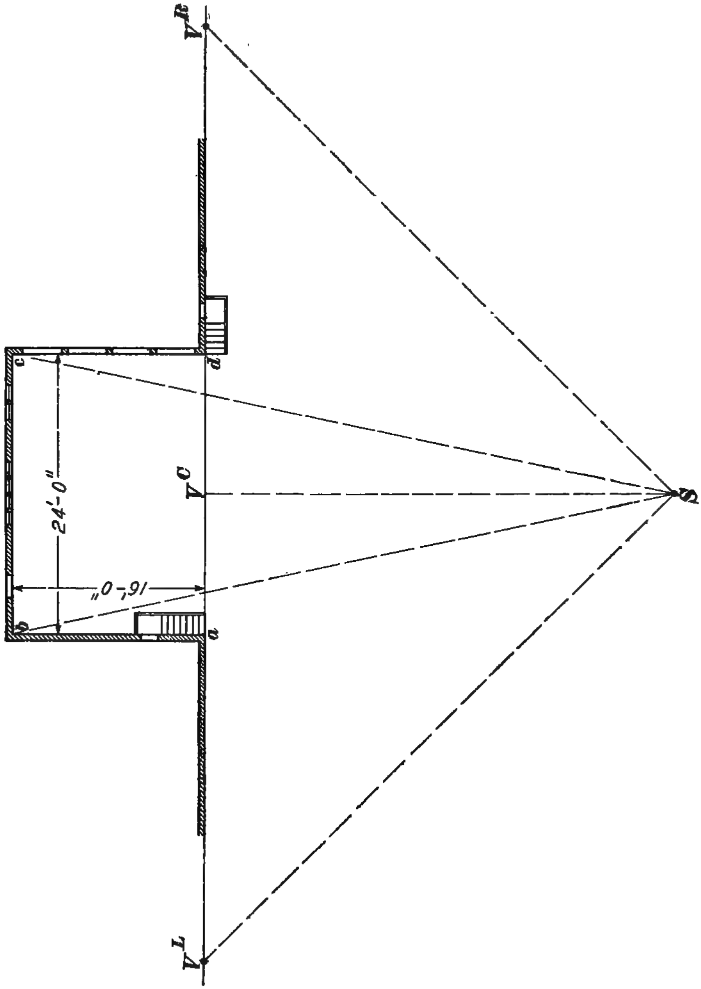


FIG. 31

44. In Fig. 31 is shown the plan of a court surrounded by buildings; the sides *a b* and *d c* of the buildings are perpendicular to the picture plane, while the side *b c* is parallel with the picture plane. It has already been explained (rule I, Art. 7) that all lines in a plane parallel with the picture plane can be drawn to the same scale, and when in contact with the picture plane may be drawn full size.

Therefore, the portions of the building in contact with the picture plane at *a* and *d* may be laid out regularly to the full scale of the plan, and the steps going up to the right from *d* may have their ends next to the picture plane laid out in their actual scale and proportionate size. The proportions of all parts of the building in contact with the picture plane may be laid out as a simple elevation and the relative lines projected therefrom toward the vanishing point V^c, so as to intersect with vertical lines from the perspective plan drawn to limit the width of the buildings in the back of the court, which are then, in themselves, drawn in elevation.

45. Change of Position of Picture Plane.—It is not at all unusual, in making drawings in parallel perspective, to reverse the order of things somewhat and to place the picture plane behind the object to be drawn, projecting the lines of sight from *S* back toward the picture plane. This is shown in Fig. 32, where the plan of the court *a b c d* is entirely in front of the picture plane. The station point is at *S*, and projection lines are drawn from the station point back through the principal points of the building until they intersect with the picture plane. The advantage in this method consists in the fact that the entire façade of the building *b c* is in the picture plane and can be drawn to scale as an elevation.

46. The effect of these arrangements, when working with a perspective plan, is shown in Fig. 33. At any convenient distance below the horizon (though in many cases the farther below the better), the perspective plan of our court is drawn as follows:

The fronts of the buildings nearest, as shown at *a a* and *d d* in the plan, are drawn to their full scale of $\frac{1}{16}$ or $\frac{1}{8}$ inch to the foot, according to the scale of the perspective required, the distance *a d* being the same as the distance *a d* in the scale plan shown in Figs. 31 and 32. The lines *a b* and *d c* converge toward V^C, and the perspective depth of the court is ascertained by laying off from *a* toward *d* a distance *a e* of 16′ 0″, which is equal to the scale depth in the plan, Fig. 31, and drawing a line to the 45° vanishing point V^L. This makes the triangle *a e b* the perspective view of a right

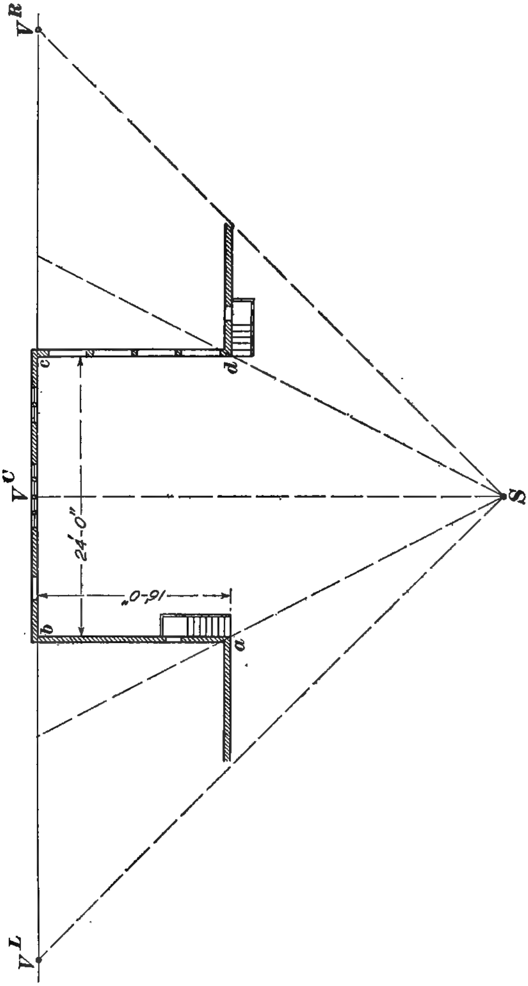


FIG. 32

triangle, with the right angle at *a* and the angles at *b* and *e* equal to 45°, the same as *abd*, in Fig. 30. Therefore, the side *ab* must equal the side *ae*.

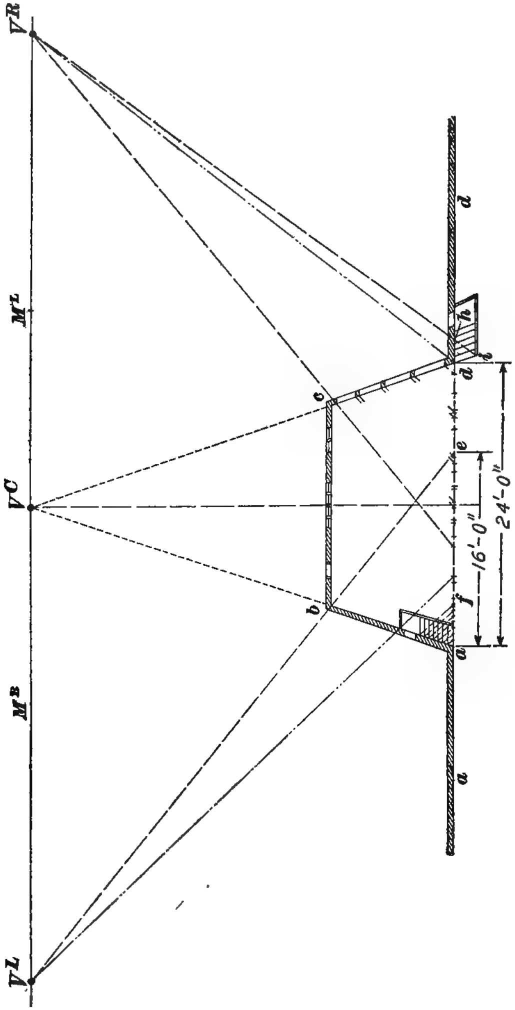


FIG. 33

47. Laying Out Plan of the Steps.—The plan of the steps is laid out in the same manner, on the left side the width of each successive tread of the steps being laid off from *a* toward *f* and lines drawn toward V^L to mark these widths on the side of the house *a b*. The width of the treads of the steps on the right side can be laid out to actual scale along the side of the house *d d*, and lines drawn from V^C through them will mark them in plan, whereas their length beyond the line *d d* is determined, as before, by measuring off a distance from *d* to *h* equal to the width of the steps and drawing a line toward V^R, thus making *d i* equal to *d h* and the triangle *d i h*, a right triangle in perspective, with its right angle at *d*. In this case, the steps are *between* the eye and the picture plane, and are therefore drawn to a larger scale than that used to draw the details actually in contact with the picture plane itself.

48. In Fig. 34, a perspective plan is laid out in precisely the same manner, except that *b c* is assumed to be in the picture plane, and this end of the court is laid out to full scale, drawing lines from V^C through *b* and *c* toward *a* and *d* and determining the length of the side *a b*, as before, by measuring from *b* toward *c* a distance *b e* of 16′ 0″, equal to the scale length of the side *a b*, also, drawing through the point *e*, so located, a line from V^R; constructing, thereby, in perspective, a right triangle *a b e*, with a right angle at *b* and 45° angles at *e* and *a*, making the side *b a* equal to the side *b e*.

49. As all lines drawn toward V^R or V^L are at 45° with the picture plane, and as all lines drawn toward V^C are perpendicular to the picture plane, it stands to reason that a line from *d* to V^R will be at 45° with *c d* and that the angles *c–d–*V^R and *d–d–*V^R are both 45°. If, then, from *h*, the point where the line from *d* to V^R intersects the picture plane *P P* the distance *h k* equal to the width of the steps in front of *d d* is laid off, and from V^R through *k* the line *k i* is drawn, there will be found, where this line intersects *c d* prolonged, the width of the steps, in perspective, at *d i*. The other steps at the corner *a* are laid out by measuring their scale width at *b f* and projecting it by means of a line from V^C through *f* to *g*.

50. Method Used in Practice.—In practice, where the plan is constructed in front of the plane of measures, as in this case, and there is much detail to be drawn on the sides *a a* and *d d*, it is wise to construct a *new scale* for use on the sides *a a* and *d d*. This can be done by simply laying off, to scale, a few equal divisions of 1 foot each on the

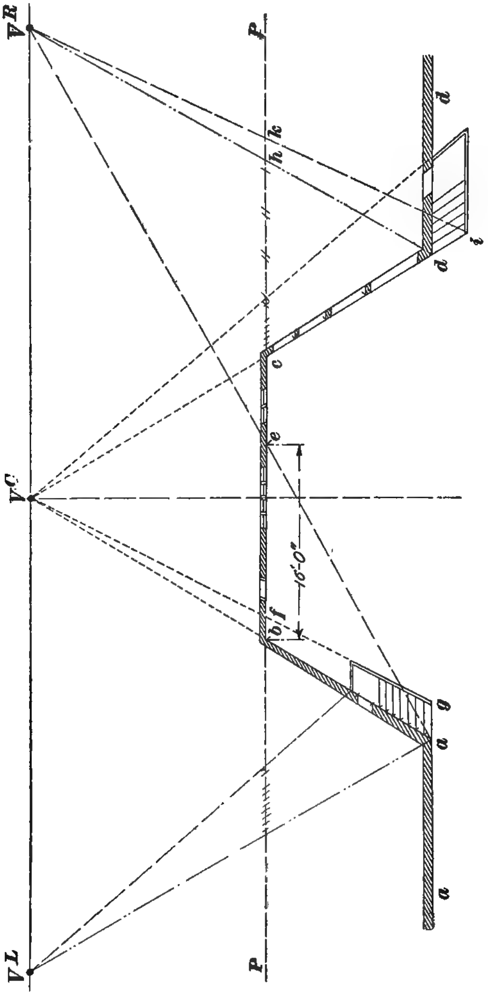


FIG. 34

picture plane and drawing lines from V^C through them until these lines intersect with a new plane coincident with *a a* and *d d*. This will give a new scale of feet by which all the details of *a a* and *d d* may be laid out.

51. Changing the Scale.—There is another condition in which a change of scale is very convenient and often imperative, which it will be well to explain here. At *a b c d*, Fig. 35, is shown a room or hall. The station point is at *S*, and the picture plane at *PP*. In order to locate in a perspective plan certain points that will give the depth of this room, it will be necessary to lay out, toward the left from *d*, Fig. 36, a distance *d f* of 70′ 0″, equal to *d c*, Fig. 35, and

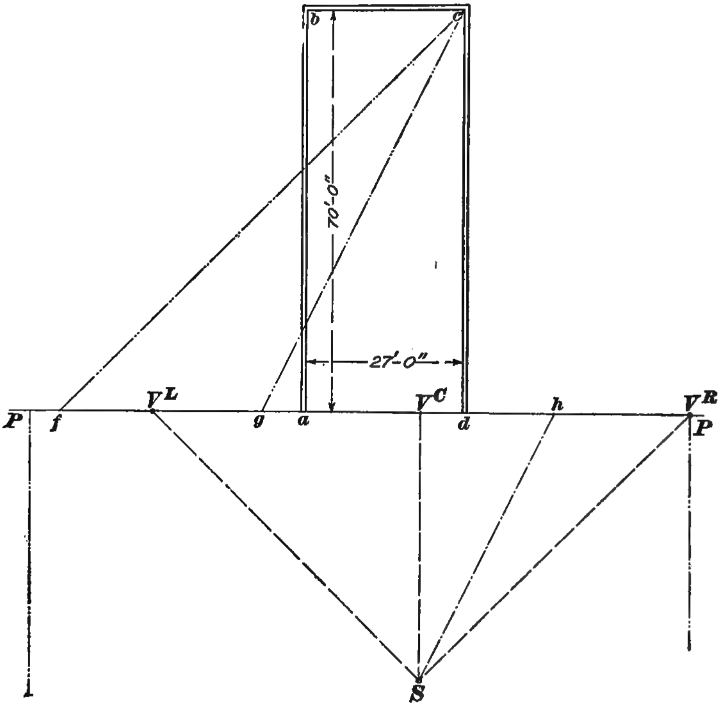


FIG. 35

draw a line from f toward the vanishing point V^R. But circumstances might be such that there will not be space to lay out so great a distance to the left of d—only space enough for one-half or one-quarter of this distance, according to the depth of the hall. Inasmuch as a line drawn from f to c, Fig. 35, is parallel with the line from S to V^R, it stands to reason that a line drawn from a point g half way between d and f toward c will be parallel with a line drawn from S to a point h, half way between V^C and V^R.

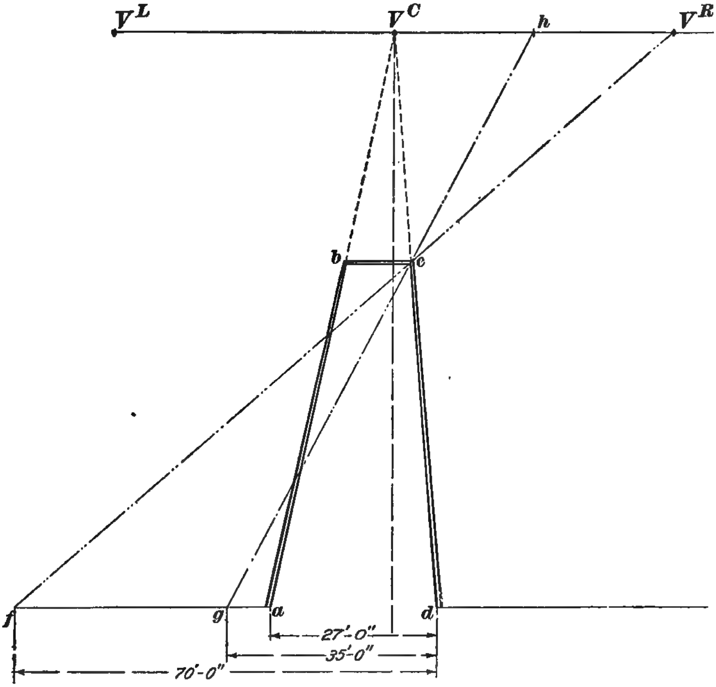


FIG. 36

Therefore, in order to locate the depth of dc in perspective, Fig. 36, lay off, to the left of d, a distance dg equal to one-half the distance dc, Fig. 35, and draw from g a line to a point h half way between V^C and V^R. This line will locate on the line from d to V^C the corner c, as shown in Fig. 36.

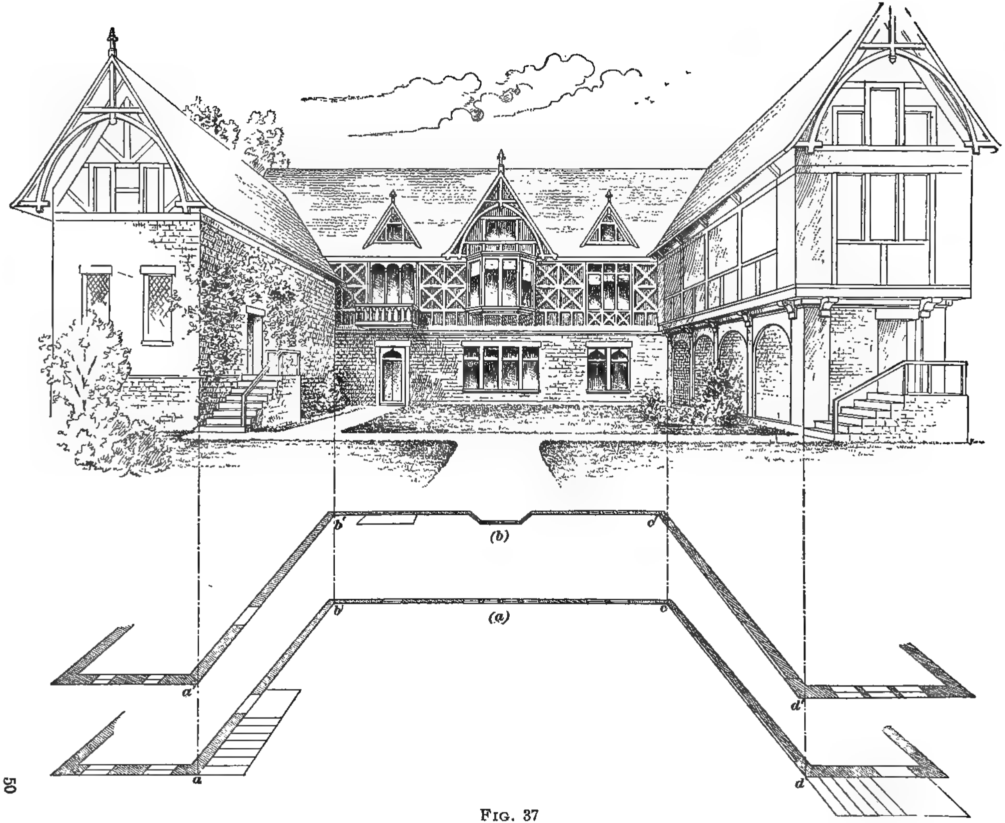


FIG. 37

52. In Fig. 37 (*a*) is shown the perspective plan of the first story of the court, and at (*b*) the perspective plan of the second story of the court, referred to in Figs. 31 and 32, and above them, drawn in simple elevation, is that portion of the façade of the building which lies in the picture plane coincident with *b c* of the plan. The steps at each side of the court are determined in the same manner as explained in Figs. 33 and 34, but it will be noticed that the façade of the second story $b' c'$ is narrower than that below, thereby showing that $c' d'$ projects slightly over and beyond *c d*. This illustrates very clearly the advantage of using a perspective plan, as all these details of projection can be shown in their relative positions without the slightest confusion, and the entire plan can be laid out with perfect convenience and all points located for proper projection into the picture.

53. Determining Proper Method of Procedure. In determining which procedure is necessary in parallel perspective—that of assuming the picture plane entirely in front of the object, as in Fig. 33, or that of having it entirely behind, as in Fig. 34—consideration must be given to the amount of distance effect that it is desired to produce. In general practice, it is convenient to determine the relative proportions of a street or interior at the very beginning. That is to say, having determined on a scale to which the nearest portions of the object are to be drawn, the most distant portions may then be drawn to any suitable size and set as far up or as far down, or to one side or the other, as will give them the best appearance. Vanishing lines then drawn through the corresponding angles of the two ends will determine V^C and the height of the horizon.

54. A clearer idea of this proceeding may be obtained from Fig. 38, wherein the elevation of the back of the court is shown drawn to scale and the fronts to the left and right of *a x* and *d y* are drawn to any desired scale—in this instance, so that the height of the eaves is *x a* and *y d*. Lines drawn from *a* and *d* through *b* and *c* meet at V^C, and thus locate the vanishing point V^C and the height of the horizon.

Other lines drawn from V^C to x and V^C to y give, in outline, a perspective plan $x\,u\,w\,y$ from which V^L and V^R may be located. From x is laid off to the right a distance xg equal to the actual scale depth of the court, and a line is drawn

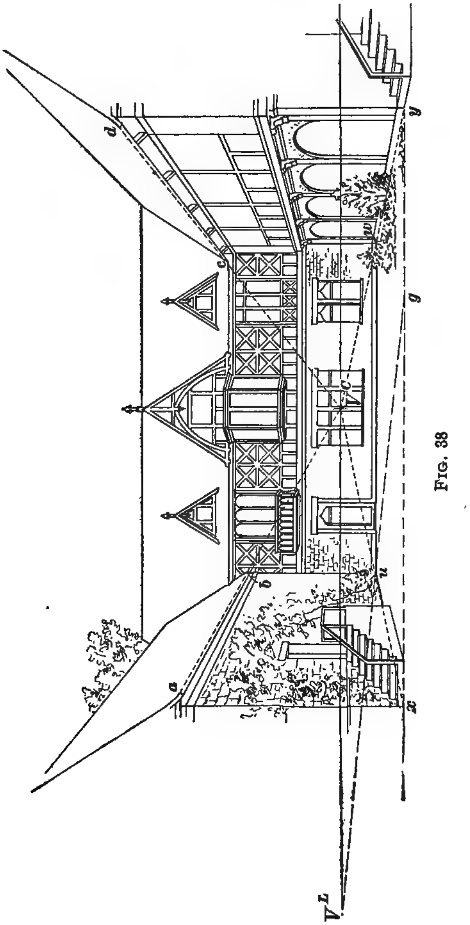
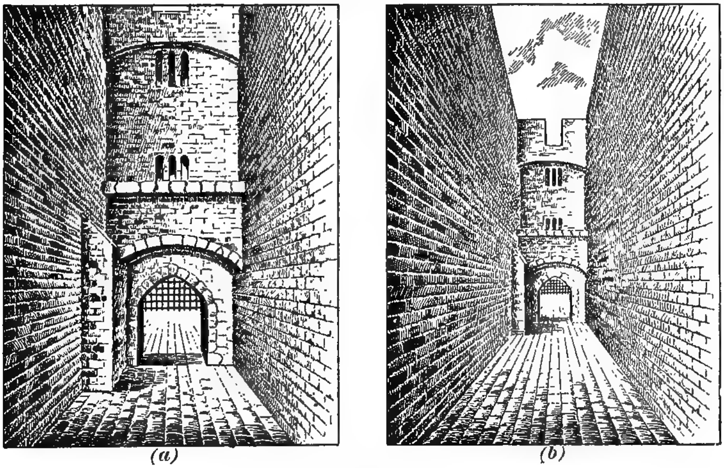


FIG. 38

from g through u until it intersects with the horizon line; the point of intersection will be V^L, and the distance V^L. V^C will be equal to the distance from V^C to S, which is the station point (see Fig. 20).

55. It may seem somewhat irregular to make a drawing by this inverse method, especially after having considered so carefully the importance of locating the station point and horizon line heretofore; but in parallel perspective, there being but one vanishing point, the effect is likely to be deceptive, as the location of the station point is not naturally taken into consideration by the spectator, and the size and proportions of objects are judged by the effect of distance instead of from the point from which they are viewed.

In Fig. 39 are shown two perspective sketches made by this method; in one of them (*a*) the station point is twice as far away as in the other (*b*), and though they are both drawn to exactly the same scale the effect is materially different. So far as the lines of the drawing are concerned, the effect of distance is produced by placing the station point near to the nearest part of the object shown, thus producing considerable contrast between the relative sizes of the nearest object and those most distant. This, however, though desirable in the representation of streets and halls, is undesirable in the representation of rooms of medium size.



(*a*) (*b*)

FIG. 39

EXERCISE III

Problem 7. Exercise III.—Draw, in parallel perspective, the row of tents shown in Fig. 40, their bases being 5 feet below the horizon, V^C to be placed exactly in the middle of the space between the two rows shown in plan in Fig. 40. Place the horizontal measuring line and perspective plan about 4 inches below the horizon. Scale $\frac{1}{4}$ inch to the foot.

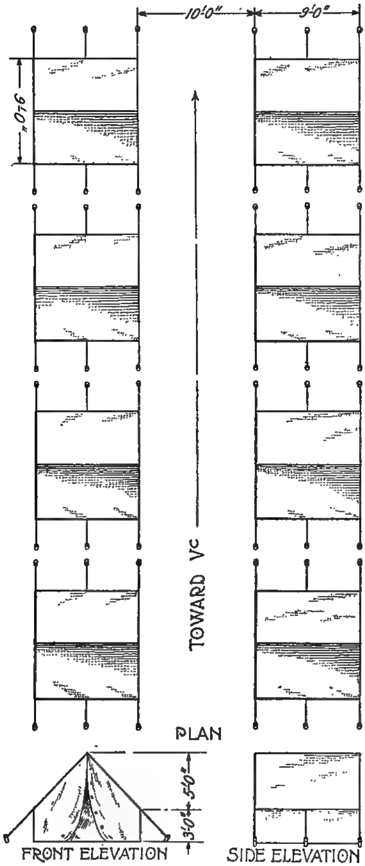


Fig. 40

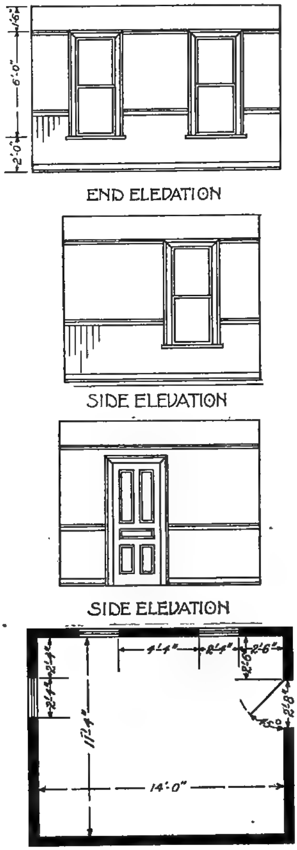


Fig. 41

PROBLEM 8. Exercise III.—Draw this same illustration, Fig. 40, with the center of vision 20 feet above the ground line.

PROBLEM 9. Exercise III.—Make a parallel perspective drawing of the room shown in Fig. 41, selecting your own station point and placing the vanishing points as desired.

PERSPECTIVE OF CIRCLES

56. Difference in Perspective Drawing of Curved and Straight Lines.—There has been considered so far only the perspective drawing of straight lines, whose vanishing points could always be located by looking in the direction of the line and observing where it pierced the picture plane. With curved lines, however, an entirely different condition of affairs is met, because, on account of their changing direction, they may not come in contact with the picture plane at all, but may remain entirely beyond it.

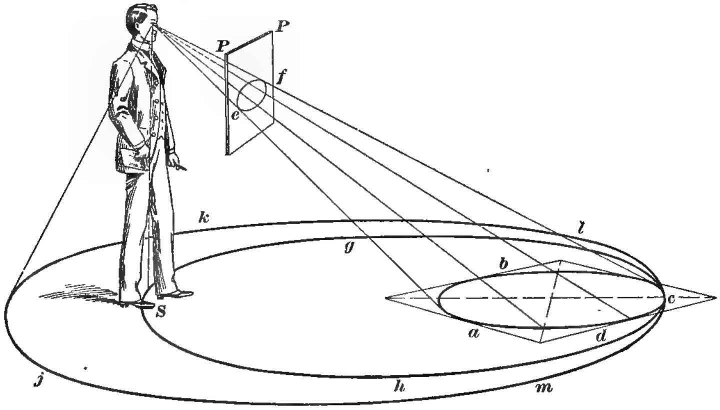


FIG. 42

57. Lines of sight, however, from the eye of the spectator to the contour of the curves will pierce the picture plane in such a manner as to locate a number of points that can be connected and represent the perspective of the arc. It will thus be understood that the spectator looking at the circle will have his lines of sight represent, in space, an imaginary cone, the base of which will be the circle in question, and the apex, the meeting of the lines of sight at his eye.

This is shown somewhat more clearly in Fig. 42, where the spectator, standing at S and regarding the circle $a\,b\,c\,d$, forms an imaginary cone of rays with his eye at the vertex and the circle at the base. If this cone of rays is cut through at any point by the picture plane, as shown at PP, its intersection will be an ellipse, as shown at $e\,f$, as it has been already learned that any section of a cone caused by a plane passing through two sides of the cone produces a circle or an ellipse. In perspective drawing, all representations of the circle are either ellipses, parabolas, or hyperbolas, according to the position of the spectator with reference to the circle.

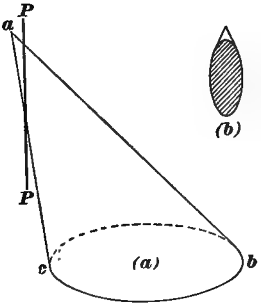


FIG. 43

58. In Fig. 42, the spectator standing at S sees the circle $a\,b\,c\,d$ as an ellipse. However, he is standing on the edge of the circle $S\,g\,c\,h$, and any portion of a curve of that circle that appears on the picture plane PP will be the arc of a parabola, and any portion of the arc of the circle $j\,k\,l\,m$, entirely within which he is standing, will appear as the arc of a hyperbola. The reason for this can be seen by a comparison with Fig. 43 (a), where $a\,b\,c$ is an oblique cone cut through by a perpendicular

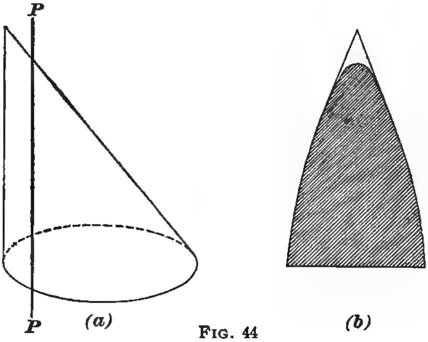


FIG. 44

plane *PP* that passes through both of its elements *a b* and *a c*. The conic section produced by this is shown at (*b*) as an ellipse, and corresponds to the conditions of the spectator in Fig. 42 viewing the circle *a b c d*.

59. In Fig. 44 (*a*), the cone is shown corresponding to that one formed by the spectator standing on the edge of the circle; it is still an oblique cone, and the plane of the picture passes through the base parallel to one of its sides, thereby making the section a parabola, as shown at (*b*). In Fig. 45 (*a*), the spectator stands within the cone itself, and the plane of the picture passes through the base of the cone and forms a hyperbola by its section, as shown at (*b*). However, in the majority of cases, the circle appears as an ellipse in perspective.

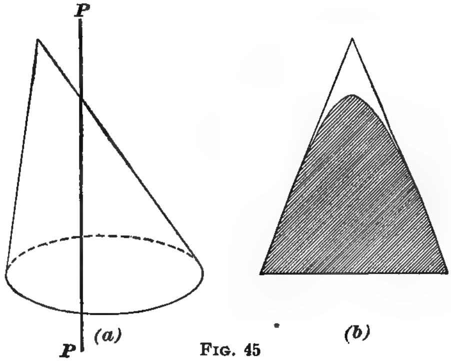


FIG. 45

60. Projection of Circular Forms. In projecting circular forms to the picture plane, it is always simplest to determine their form by means of relative points on straight lines. As has been shown, it is a simple matter to project a perspective view of a rectangle. If now the circle is considered enclosed in a square, as shown circumscribed in Fig. 42, it will be easy to draw that square in perspective and to note where the circumference of the circle intersects the diagonals of the square. These points and the points of tangency on the four sides of the square will give eight points on the picture plane, through which can be drawn the ellipse representing the perspective of the circle.

61. In Fig. 46, at *m m*, is shown a measuring line on which *a*, *e*, *d*, and *b* are laid off in the proportion of the side of an enclosed octagon, as in Fig. 20. The octagon enclosed in a square is then drawn in perspective, as at *a b′ c′*, and within it the circle is drawn freehand as shown.

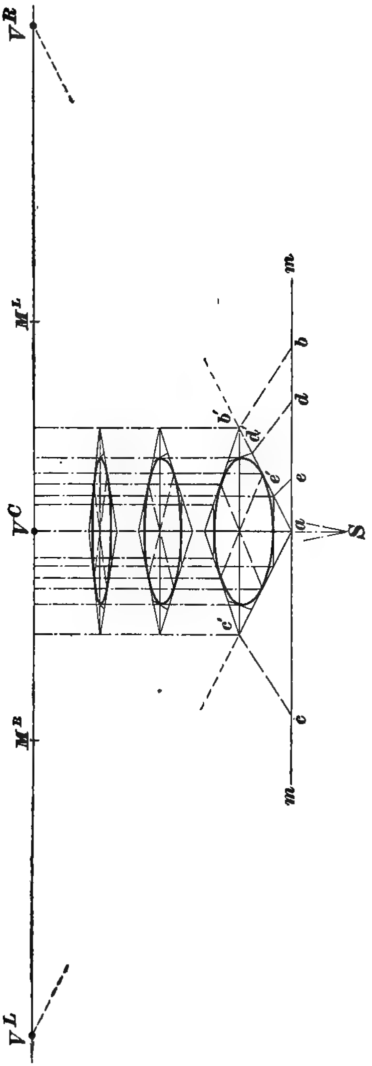


FIG. 46

62. Where the circle is not in a horizontal position, the proceeding is exactly the same as shown in Fig. 47, where an arch is given, whose plan presents no data for the proportioning of the curve except its perspective diameter. However, in constructing the perspective elevation, there is given, in perspective, a parallelogram *a b c d* that is the perspective representation of the parallelogram *a′ b′ c′ d′* in the elevation to the left containing the semicircular arch of the opening.

The lines through the corners of this parallelogram that give us the octagon shape are located from the plan in precisely the same manner as before, the points being laid off on the measuring line *m m* and projected to the line *b c* directly from the perspective plan. The point *e* on the side *a b* of the rectangle in the perspective elevation may be located by setting off its

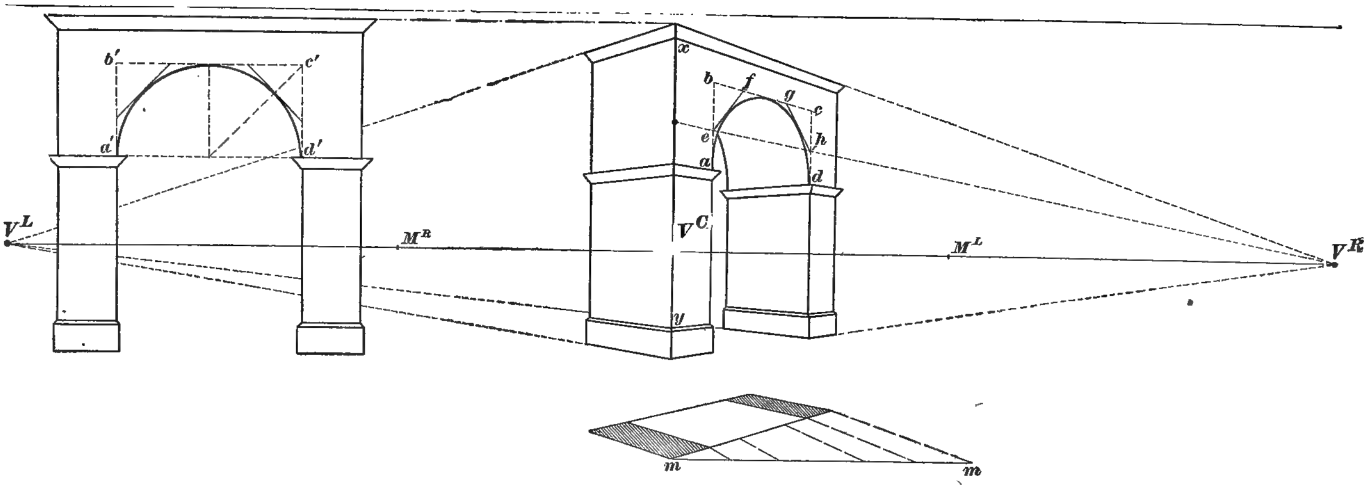


FIG. 47

true height on the corner of the arch *x y*, which is in the picture plane, and projecting it to its true place by a line toward V^R, as shown; or, after locating *f*, a line may be drawn through *f* toward V^{M45}—the vanishing point of lines inclined at an angle of 45° above the horizon. The side *g h* of the octagon can then be simply drawn toward $V^{M'45}$, or the points may be projected from the corner *x y* of the arch and drawn in as before suggested, the construction of the ellipse after the octagon is formed being simply a matter of freehand sketching.

63. In Fig. 48 is shown an ordinary cast-iron pulley wheel, the perspective rendering of which consists almost entirely of ellipses. In this case, as before, the circle representing the rim of the wheel is considered as being enclosed in a rectangle or octagon, as shown at *a b c d*. The perspective of this rectangle appears in the form of a rectangular box, inasmuch as the wheel has considerable thickness, and two ellipses are drawn for the rim—one in the front of the box and the other in the bottom of it. The hub of the wheel in the middle is constructed in a smaller rectangle in the same manner. The lines at the top and bottom of the wheel that connect the ellipses and represent the thickness or breadth of the rim are drawn toward V^L as shown.

64. In Fig. 49 is shown another wheel, the rim of which is much narrower than the previous one, and for all practical purposes the two ellipses that form its rim might be drawn alike. The points on the interior of the rim where the spokes are inserted can be projected from the elevation and carefully drawn within the ellipse after the hub has been located according to lines projected from the plan.

65. In drawing circles in perspective, no serious difficulty will be met, if they are always considered as polygons having an infinite number of sides drawn within a rectangle. Methods have been shown by which a rectangular surface, no matter what may be its inclination or position, may be easily drawn in perspective, and in the preceding problems the plans of the houses, the perspective elevations of their

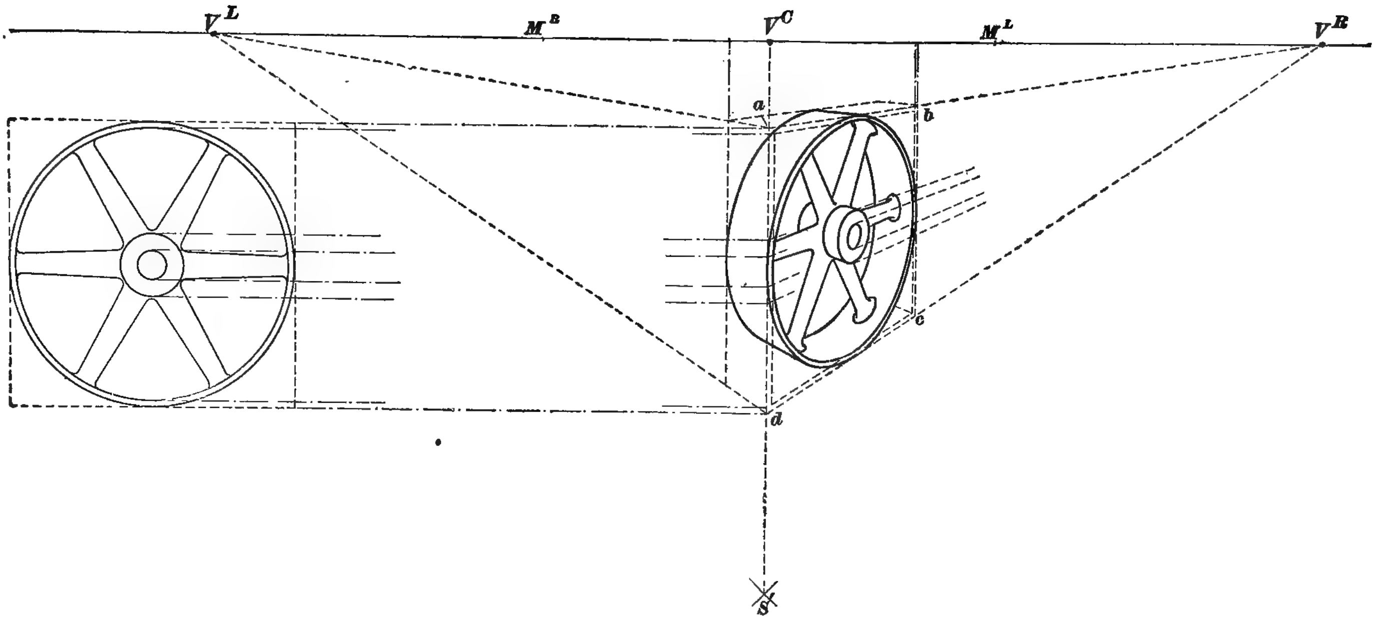


FIG 48

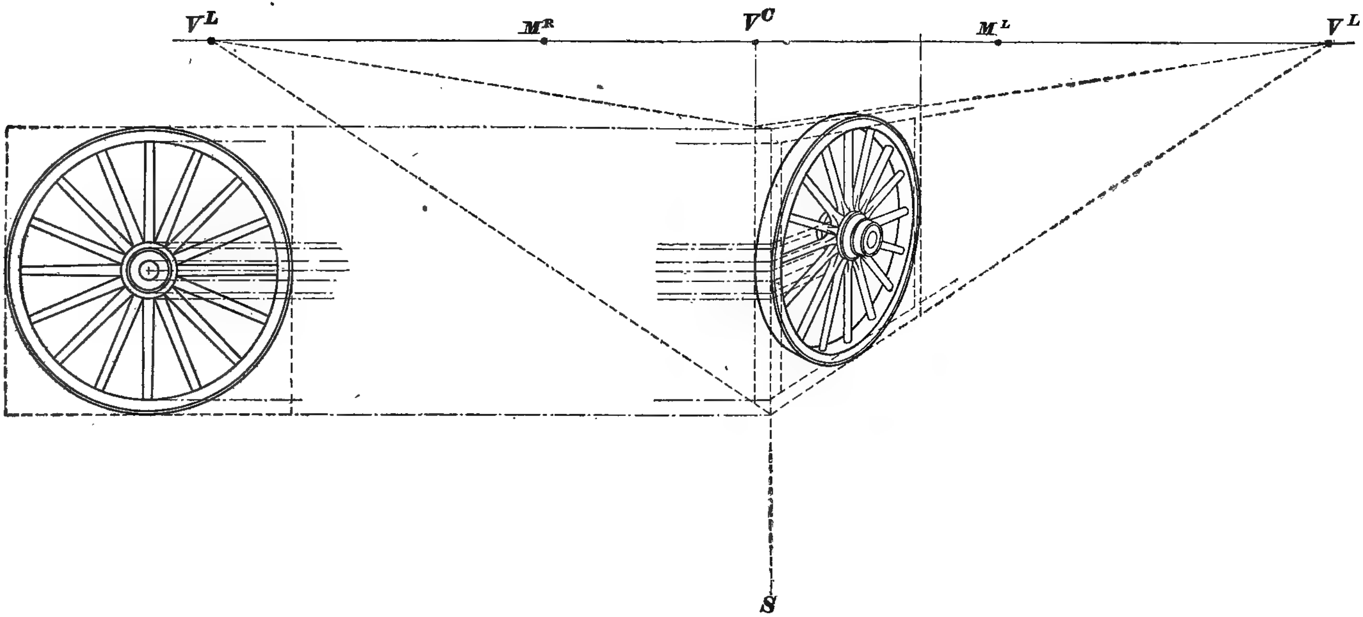


FIG. 49

sides, the surfaces of their roofs, etc. all represent rectangular surfaces in different positions and at different inclinations.

Any square can be drawn in a similar position, and when once projected in perspective it is a simple matter to convert the square into an octagon by locating on its sides the points in perspective where the extra sides of the octagon will intersect. These sides may be again divided into four parts, and, from the extreme part on each side, lines may be drawn converting the perspective of the octagon into a figure having sixteen sides, which in the majority of cases will be so near a circle that it will require simply a gentle curving of the lines in order to produce the ellipse that represents the circle in perspective.

66. Laying Out Circles.—It is frequently convenient to lay out these circles on a separate piece of paper, and having perfected the ellipse that represents one circle in perspective, to trace it off and transfer it to the drawing where it is required. For instance, in Fig. 50 (*b*) is shown what might appear to be a globular cage or basket composed of eight circles sprung together in zones. To lay out all the construction lines necessary to draw this figure would confuse the drawing very materially; therefore, it is more convenient to lay over the perspective rendering a piece of paper and to draw separately thereon each ring or ellipse; having perfected which, it may be traced and transferred to the final drawing, in order to produce the finished result.

67. Fig. 50 (*b*) consists of three vertical circles and five horizontal circles, the vertical circles all being the same size, but the horizontal circles being of three sizes according to their positions on the sphere. At (*a*) is shown the elevation of one of these vertical circles enclosed within the dotted square, on which the positions of the horizontal circles are also shown by means of the lines $a\,b$, $c\,d$, $e\,f$, etc.

In order to represent this figure, the cube $l'\,m'\,n'\,u'\,s'\,t'$ is first drawn, and on its edge $o'\,s'$ is located the point f' half way between o' and s'; $f'\,e'\,w'\,v'$ will then be a square

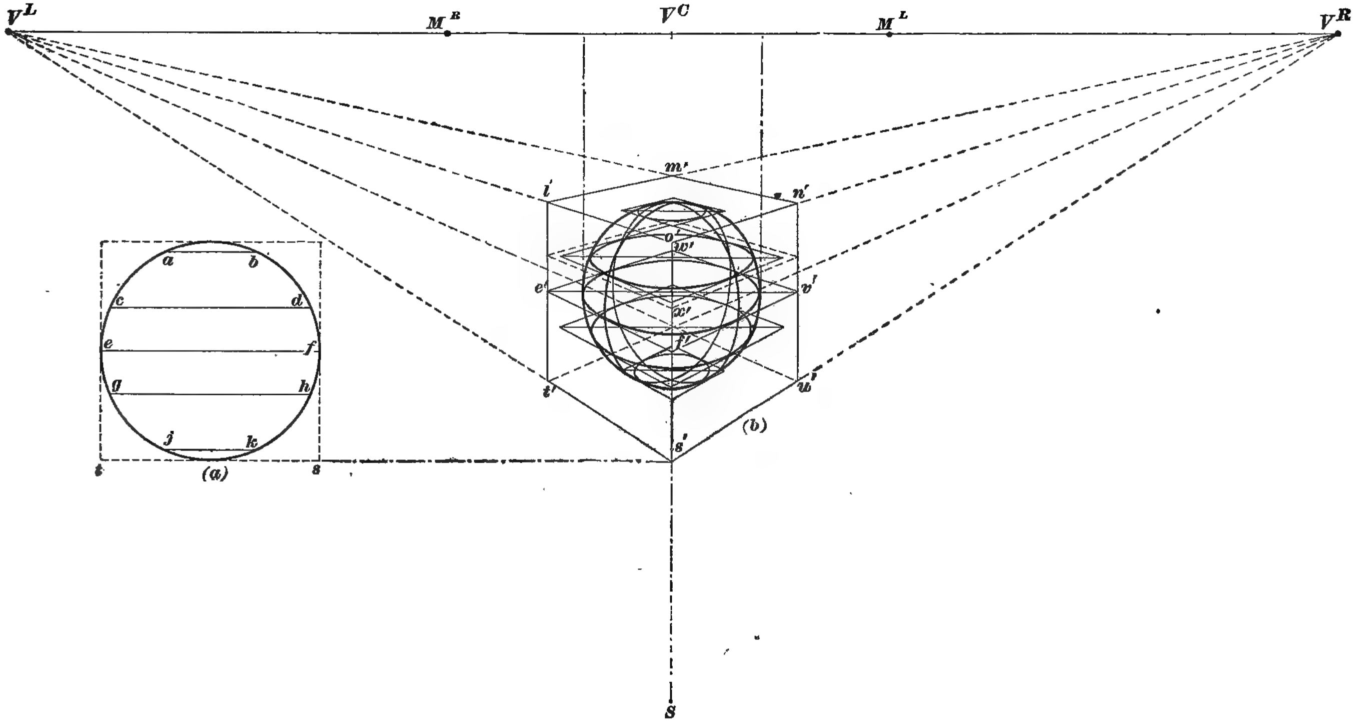


FIG. 50

containing the largest horizontal circle *e f*. The other two circles, above and below, are then located in smaller squares that are drawn in their relative positions. To draw these, it is convenient at first to locate a large square immediately over $f' e' w' v'$, the corner of which touches the edge of the cube $o' s'$ at x', which is a point on a level with the circle *c d*, as shown in the elevation (*a*). The smaller square containing the circle *c d* may be then drawn, as shown at (*b*), and the other circles located in their relative positions in a similar manner. In doing this, the perspective of the squares containing the ellipses are all that need be shown on the original drawing. These can then be redrawn on a separate piece of paper, and the ellipse sketched in, and, when perfect, traced in its proper place on the perspective drawing, as shown.

PRACTICAL PROBLEMS

68. The following problems are for practice, and need not be sent in as exercises except where expressly directed to do so. The problems are introduced to illustrate practical applications of perspective drawing in its several phases, and the construction lines are left in each case so that the problems may be worked out for practice if so desired; or they may be referred to as a guide to similar problems as they present themselves.

PROBLEM I

69. In Fig. 51, two views of an octagonal prism are shown, one above the horizon and the other below it. The square containing the octagonal base is 2½ inches on each side, and therefore, on the measuring line *A B*, 2½ inches is set off from *a* to *b* each way, and *a d* and *b c* are laid off equal to one-half the diagonal of the square, so as to divide *a b* in the proportions of the side of a square and enclosed octagon. The vanishing points V^L and V^R are 20 inches apart, and lines drawn from *b*, *c*, and *d* toward the measuring points will intersect lines drawn from *a* toward the vanishing points, so as to lay out the octagon, as shown. The height of the prism, or its distance above or below the horizon, is immaterial in this problem, and these details may be arranged in any satisfactory manner. The prism may also be placed to the right or left of the center of vision somewhat if desired. The drawing is to be made on a sheet of 9″ × 12″ paper, with a ½-inch border as usual, but the problem will require a full-size drawing board.

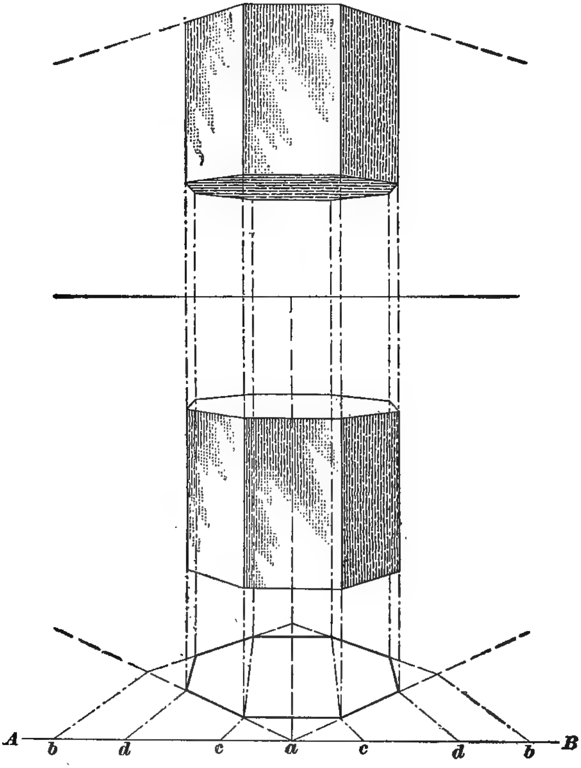


FIG. 51

For the drawing of this and successive problems, it will be well to draw in ink on the drawing board a line representing a horizon, on which is located at the proper places the center of vision and measuring points. In making a perspective drawing at any time thereafter, two pins may be inserted at the vanishing points, and with the edge of the **T** square

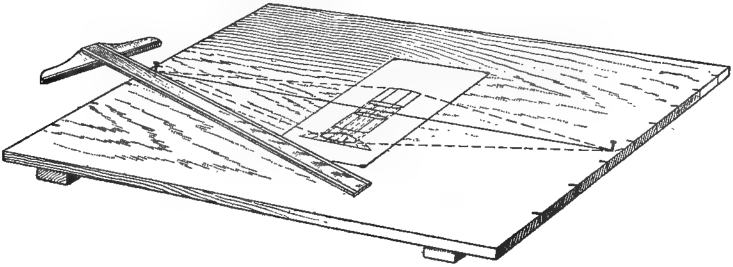


FIG. 52

working against them, problems may be solved on smaller sheets placed at the proper places (see Fig. 52).

PROBLEM II

70. Fig. 53 shows a flight of steps. These steps are each

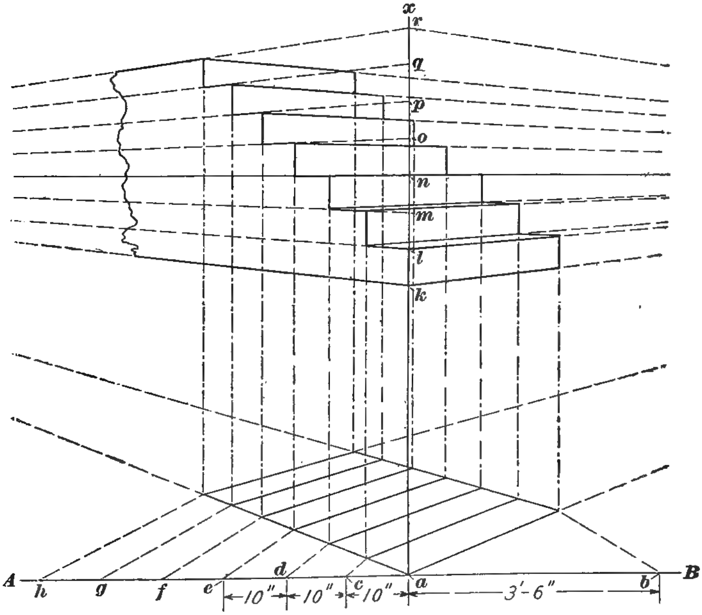


FIG. 53

6 inches high and 10 inches wide, and their width is 3 feet

6 inches. In laying out the perspective plan, *a b* is laid off on the measuring line *A B* equal to 3 feet 6 inches, the width of the steps, and *a*, *c*, *d*, *e*, *f*, *g*, etc. are each laid off 10 inches, representing the width of each step. Lines drawn from these points to the measuring points will intersect with lines drawn from *a* to the vanishing points, and will give the points from which the perspective plan of the steps can be drawn. The vertical line *a x* can then be drawn from *a*, the point where the perspective plan touches the measuring line, as the line on which the vertical measurements are to be determined, and the points *k*, *l*, *m*, *n*, *o*, *p*, *q*, and *r* are then laid off 6 inches, each representing the height of each of the risers. Lines drawn from these points to V^L will determine the height of each riser, and the perspective width of the tread can be projected up from the plan as shown.

Draw the perspective plan and elevation of these steps, as shown in Fig. 53, at a scale of $\frac{3}{4}$ inch to the foot; and use 9″ × 12″ paper with a border line $\frac{1}{2}$ inch within the margin.

PROBLEM III

71. In Fig. 54 is shown a bookcase, the front and side elevations of which are illustrated in Fig. 55. The perspective plan of this bookcase is drawn out as shown in Fig. 54. Some complication may arise here, as the measuring line is drawn through the corner of the case itself, whereas the top of the bookcase projects 1 inch on three sides. In laying out the plan, the distance *a b* is laid off 2 feet on this measuring line the entire width of the bookcase, and *a*, *c*, *d*, *e* and *b*, *c*, *d*, *e* are laid off 1 inch each to mark the thickness of the ends of the case, the width of the bottom of the foot and the width of the top of the foot, being 1, 2, and 3 inches, respectively. At *e*, *f*, *g*, *h*, etc. are laid off the widths of the books on the lower shelf—2 inches each. Lines drawn from these points toward the measuring point M^R will intersect a line drawn from *a* toward the vanishing point V^R and enable the perspective plan to be constructed.

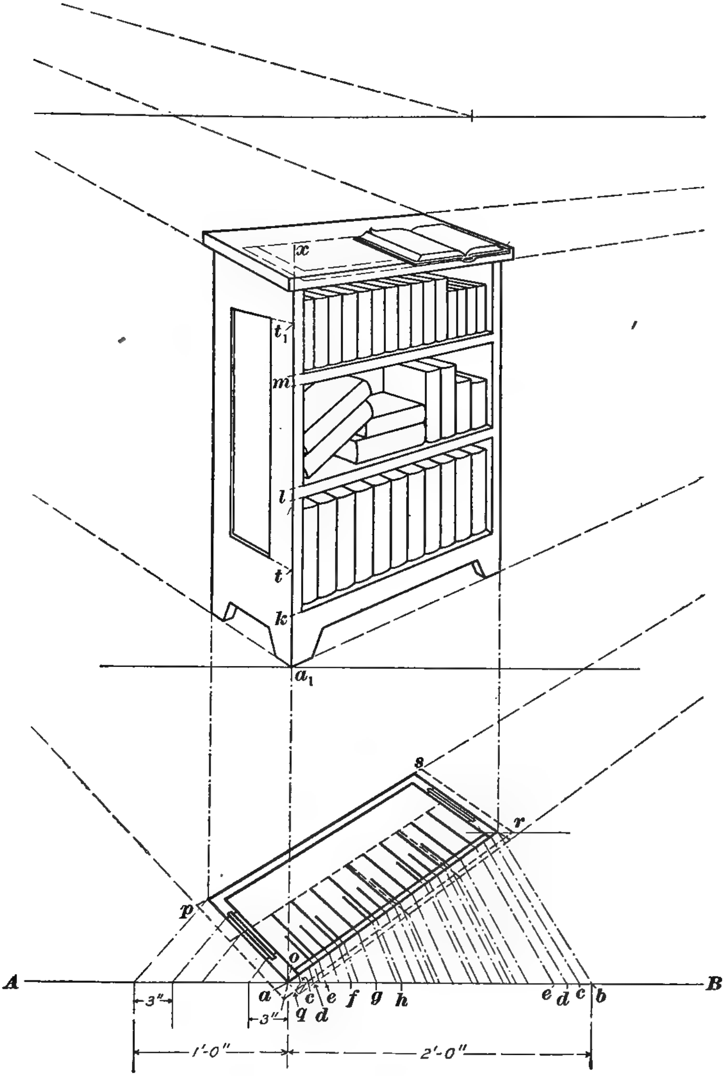


FIG. 54

The corner of the case shown in the elevation $a_1 x$ has marked on it, according to scale, the heights of the lower shelves at *k* and the thickness and position of the two other shelves at *l* and *m*. These are projected across the case toward V^R, and located in their proper places. The inclination of the top and its projection over the sides is found by drawing the line from V^C through *a*, as indicated on the plan by the line *a o*. This is the diagonal of the corner. The projection of the top of the bookcase is 1 inch; in other words, it projects beyond the end of the case the distance *a c*.

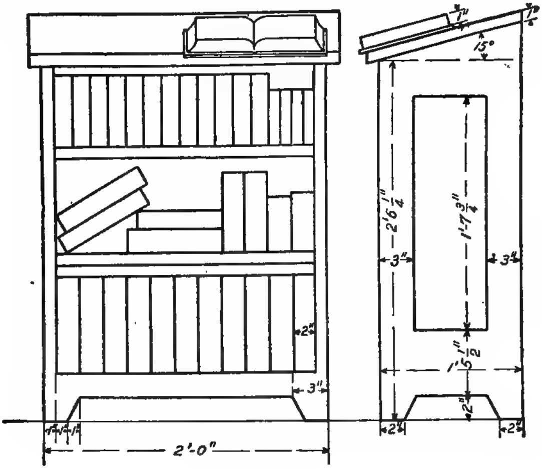


FIG. 55

If, therefore, a line is drawn from M^L through *c* until it intersects with the side of the case prolonged, as from *a* to *q*, it will mark this projection. A line drawn through *q* toward V^R will show the projection of the top over the front of the case, and where this line intersects, the line *a o* will show the projection as it returns around the end of the case. This projection should be indicated by a dotted line drawn toward V^L to *p* and toward V^R to *r*, where it will intersect a horizontal line through the corner of the case and then return toward V^L to *s*. The width of the end is found by laying off 1′ 0″ from *a* toward *A* on the measuring line, the panel being indicated by laying off its width between these points, as shown. The height of the panel and its position above the floor is indicated by locating on $a_1 x$ the points t and t_1, according to measurements shown in Fig. 55. The inclination of the top will be indicated by finding the vanishing point of the inclined plane of which the top is a part. From M^L, at an angle of 15° to the left, a line is drawn locating a vanishing point directly over V^L. This will be the vanishing point of lines at 45° with the horizon and inclined upwards 15°, and lines drawn toward this point from the corners of the top projected from the plan will locate the position of the top in the elevation. The position of the books on the lower shelf should then be drawn in from the plan and indicated as shown, about 1 inch inside of the edge of the shelf. Now, draw the upper-shelf books in the plan, each of the larger books being 1½ inches thick and each of the smaller ones 1 inch thick.

All the details have now been completed except the drawing of the open book that lies on the top of the bookcase. The outline and center fold of this book should be carefully drawn in the plan, Fig. 54, by laying off the required width from b toward a on the measuring line AB and projecting lines to M^R, as shown by the dotted lines. It will be observed in the elevations, Fig. 55, that the front edge of the book projects over the desk somewhat, and that the right-hand end is about even with the vertical side of the case. The projection of this book may be determined in the plan by laying off a distance to the right of a on the line AB equal to the projection, and drawing a line from M^L through this point until it meets the end of the bookcase prolonged. A line from this point of intersection to V^R will give the required projection. The width of the book, as shown in the side elevation, Fig. 55, may be found by laying off the distance to the left of a on the measuring line AB, and projecting a line to M^L until it intersects the line from a to V^L. This is shown in the plan, Fig. 54.

The thickness of the open book should now be laid off on the line $a_1 x$ as it would appear if in contact with the picture plane, and lines from V^N 15° through these points should be prolonged to meet a vertical line from the projection of the book in the plan. Lines from these points to V^R will give the front and lower edge of the bookcover. The edges and center may now be projected from the plan to meet these lines, and the leaves and center fold indicated by lines from the points of intersection to V^N 15°. The width of the book should then be projected from the left side of the plan to the top of the case and then to V^R, as shown. The leaves may be rounded in toward the center freehand, as projected up from the plan, and the concave edges of the outer leaves may also be sketched freehand.

In working out this problem, the corner of the bookcase should be $1\frac{3}{4}$ inches to the left of V^C, the point a_1 $5\frac{1}{2}$ inches below the horizon, the vanishing points 20 inches apart, and the bookcase drawn on a scale of $1\frac{1}{2}$ inches to the foot.

PROBLEM IV

72. Problem IV presents a simple rush-seated chair with a slat back, as shown in Fig. 56. It may be drawn on a scale of $1\frac{1}{2}$ inches to the foot, and in the illustration the point a is $5\frac{1}{2}$ inches below the horizon and $2\frac{1}{2}$ inches to the left of V^C. The square within which the four legs and seat are shown in plan is 15 inches on each side. The diameter of the turned legs is $1\frac{1}{2}$ inches, so that these can be laid off at each corner of the square. The height to the top of the front legs $a\,b$ is 14 inches, and to the seat is 13 inches, thus showing that the legs project 1 inch above the seat in front. The height of the back legs continued up to form the chair back is 33 inches, which distance is laid off on the line $a\,x$, locating the height at y. Lines drawn from a and y to V^L will then determine the proportions of the back leg. The positions of the back slats are also laid off on the line $a\,x$, as shown at $v\,w$, and below, and their dimensions projected to the chair back by lines to V^L, as shown at $u\,t$. Lines from $u\,t$ to V^R show the position of the slat across the back of the chair. Other details are similarly located.

The whole chair may be detailed accurately according to

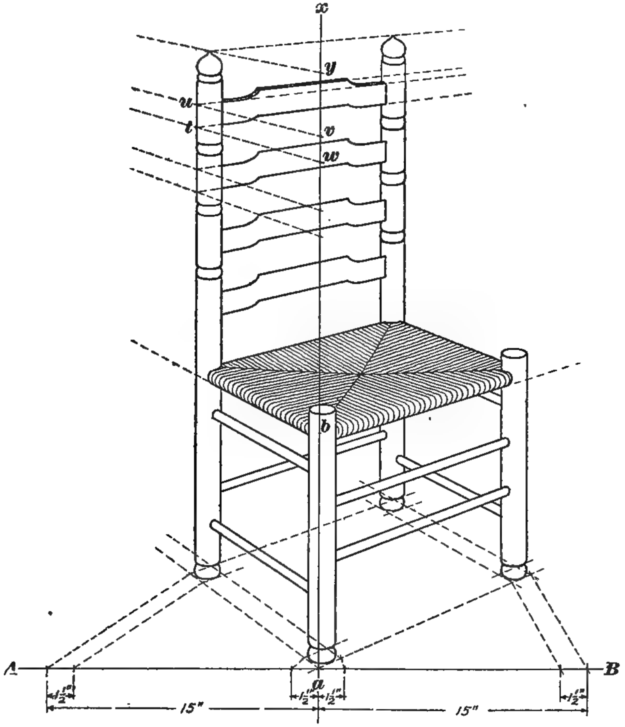


Fig. 56

measurement if so desired, or the principal lines may be located as just described and the sketch finished up freehand.

PROBLEM V

73. In Fig. 57 is shown another chair similar to that in the preceding problem, but not so uniform in its outline. This chair is 16 inches in front and 16 inches deep from front to back, but tapering so that the full width at the back is only 12 inches at the seat and 10 inches where the legs touch the floor. In drawing this chair in perspective, *a b* and *a c* are laid off 16 inches each, and lines are drawn from the points *b* and *c* toward the measuring points until they intersect lines drawn from *a* toward the vanishing points. In this way, the rectangle containing the entire seat plan can be laid out. The legs of the chair where they rest on the floor are 1 inch square, and therefore *a d* and *c e* are laid off 1 inch, to mark the perspective width of the front legs, and *a f* and *c g* are laid off 3 inches each from *a* and *c*, so as to make the distance *g f* 10 inches—the outside measurements across the back legs where they rest on the floor; *c h* and *a j* are then laid off 2 inches each, so as to make the distance *h j* 12 inches—the width of the seat of the chair at the back. Now, these points can be projected from the line *a c* to the perspective side of the rectangle containing the seat by drawing lines toward M^L, and those for use in the back can be again projected as required toward V^R. The 1-inch square representing the base of the foot should be drawn in the plan, and the legs should be drawn into the seat line as

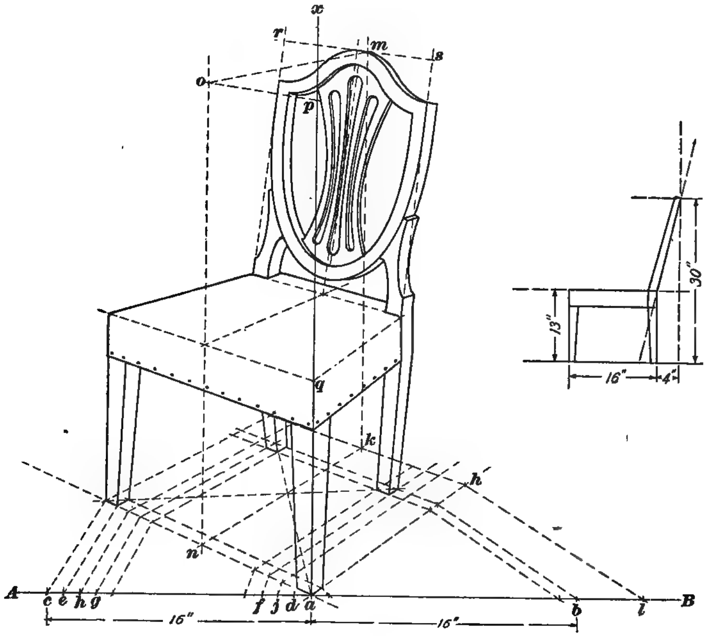


Fig. 57

shown, gradually extending to give the taper required. In accurate work, the width of the legs could also be laid off and projected to the top, giving the exact taper, but under general conditions this can be judged by the eye. The back of the chair is not perpendicular, as was the case in Fig. 56, but inclines so as to overhang at the top 4 inches, and the amount of this overhanging can be laid off from *b* to *l* and projected as shown. The rectangle enclosing the back of the chair can then be drawn in its proper position, and the ornamental figure can be sketched within it accurately. The balance of the work is entirely freehand.

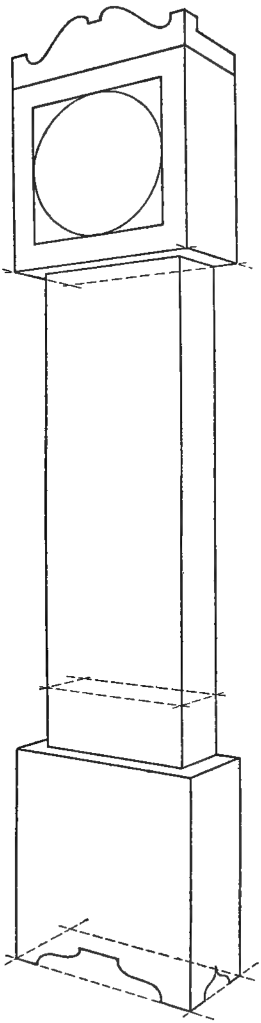


FIG. 58

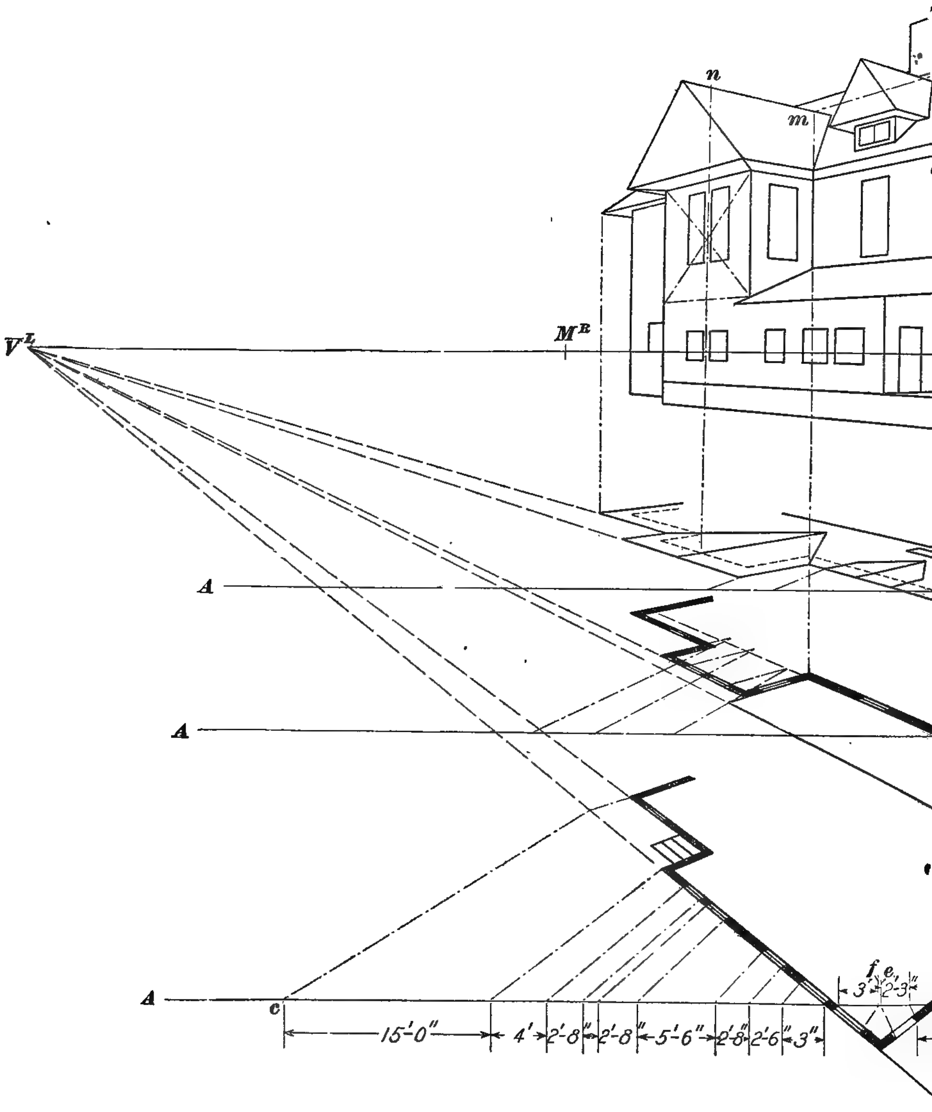
PROBLEM VI

74. There is nothing new in Problem VI, but it is introduced simply as a suggestion, showing the simplest way of working. The plan on the floor, as shown in Fig. 58, is drawn directly at the base of the old clock case itself, whereas the plan of the middle section is drawn just above the lower section, and the plan at the top is drawn at the base of the top. In this way, the plans can all be erased when they are no longer required, and the details of the clock can be sketched in almost entirely freehand. Pieces of furniture of this character can thus be rapidly introduced into perspective interior without going through a long preliminary operation of finding absolute vanishing points. In fact, for general work, the whole perspective can be suggested freehand and the vanishing points assumed afterwards in such a position as to give the desired effect, and the whole drawing worked up accurately according to the preliminary freehand sketch.

PROBLEM VII

75. In Problem VII is given the application of the principle stated in Art. **74**, in a house plan, where the three stories of the house present different complications in plan. The orthographic projection of the plans is shown in Fig. 59, where (*a*) is the first-story plan; (*b*), the second-story plan; and (*c*), the roof plan drawn to a scale. In making a perspective, the line of measures may be placed in contact with the plan at the angle of the second story *a* or the angle of the first story *a′*. The former is deemed preferable, as it keeps some part of the building in contact with the line of measures throughout the perspective drawing, as shown in Fig. 60.

In the second story, on the line of measures *A B*, Fig. 60, the corner of the building is fixed at *a*, and the perspective plans are worked out according to the two visible sides of the house. The first-story plan then shows a portion of the building extending beyond the measuring line, which may introduce a few complications in the projection but presents no difficulty, whereas if the corner of the first story at *a′*, Fig. 59 (*a*), had been placed in contact with the measuring line, it would have thrown the corner of the second story away from the line and out of the plane of measures. From *a* to *b* in the first-story plan, all the measurements for the house front are laid off on one side, and from *a* to *c* the measurements for the side elevation. Immediately over this and in the proper position, the second-story plan is also laid out. Now, on the front is shown one window and on the side one window, which are thrown in front of the picture plane, as well as is the corner of the house. From *a*, therefore, to *f* and *e* are laid off the locations and distance of the front window and corner, and from M^R a line through *e* locates this window in relation to the corner of the building.



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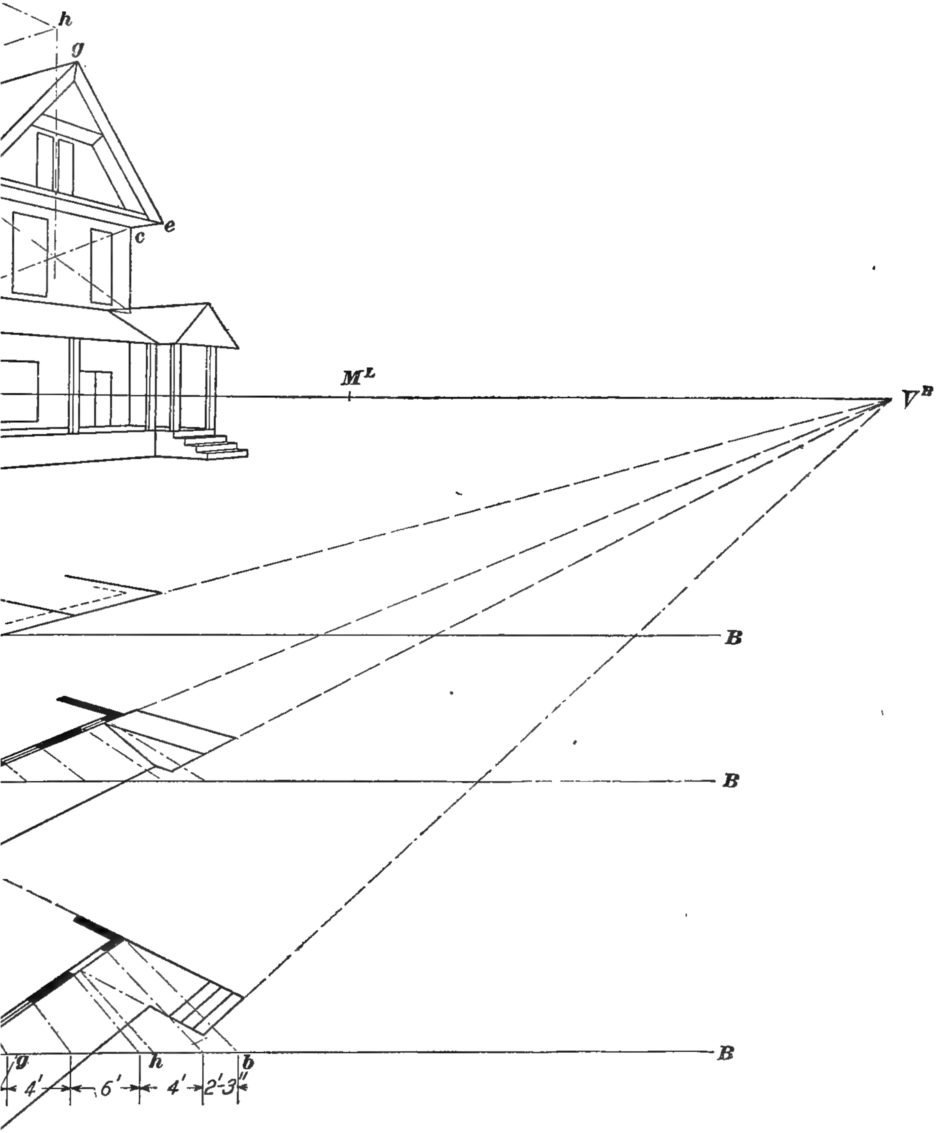
h
g
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B
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h
b
B
4'
6'
4'
2'-3"

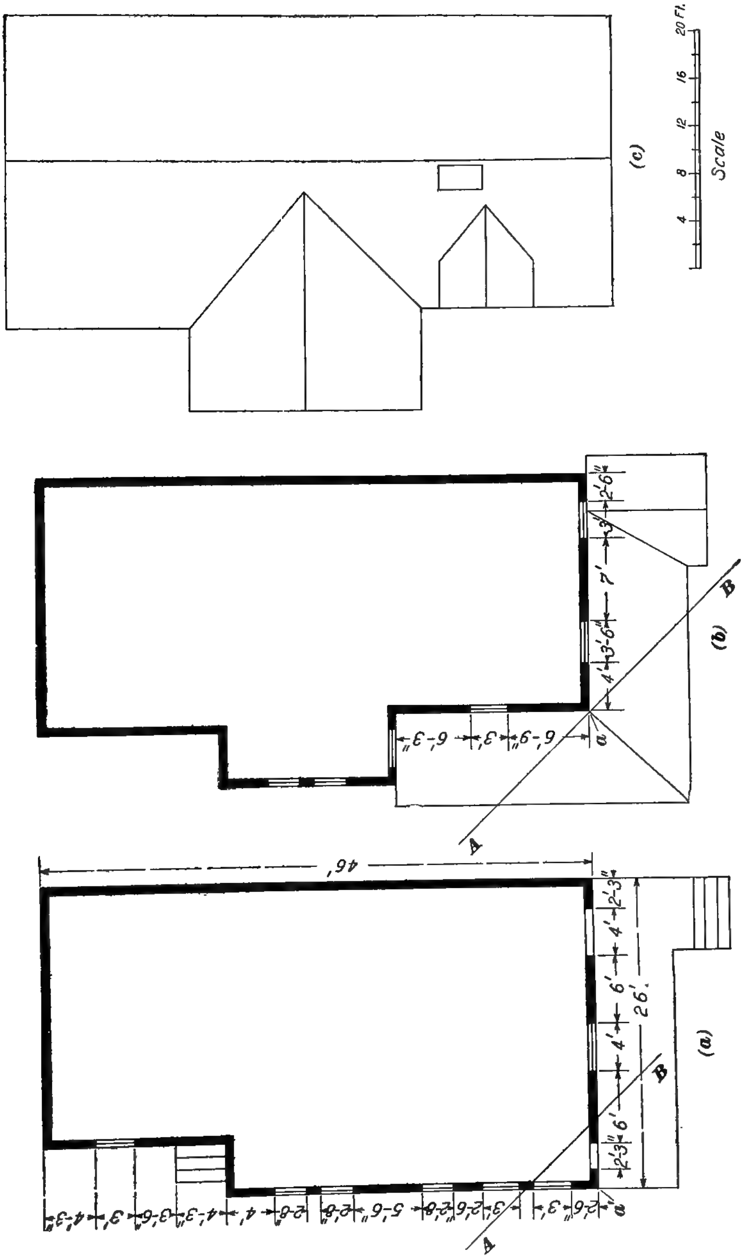

(a)
(b)
(c)
46'
26'
2'-3"
4'
6'
4'
6'
2'-3"
4'-3"
4'-3"
3'
3'-6"
4'-3"
4'
2'-8"
2'-8"
5'-6"
2'-8"
2'-6"
3'
3'
2'-6"
a
A
B
2'-6"
3'
7'
3'-6"
4'
6'-3"
3'
6'-9"
a
A
B
Scale
4
8
12
16
20 Ft.

Fig. 59

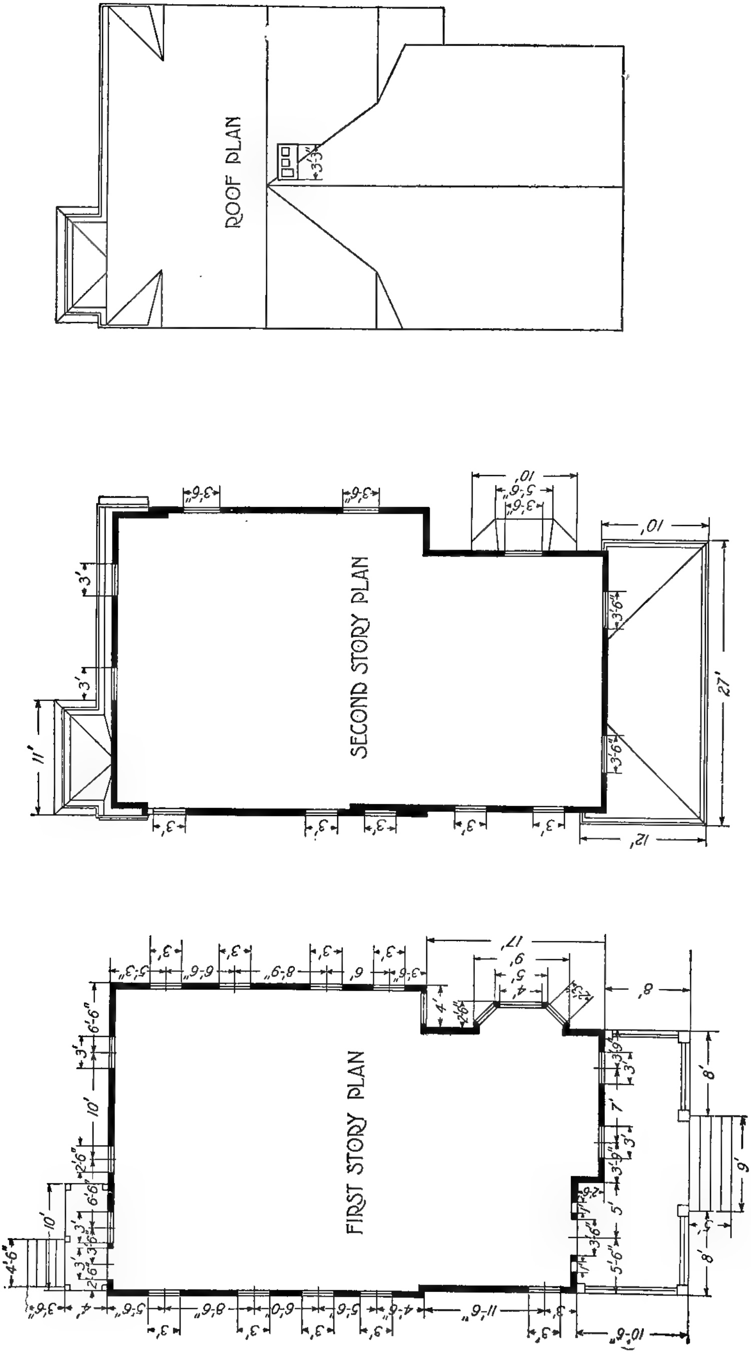
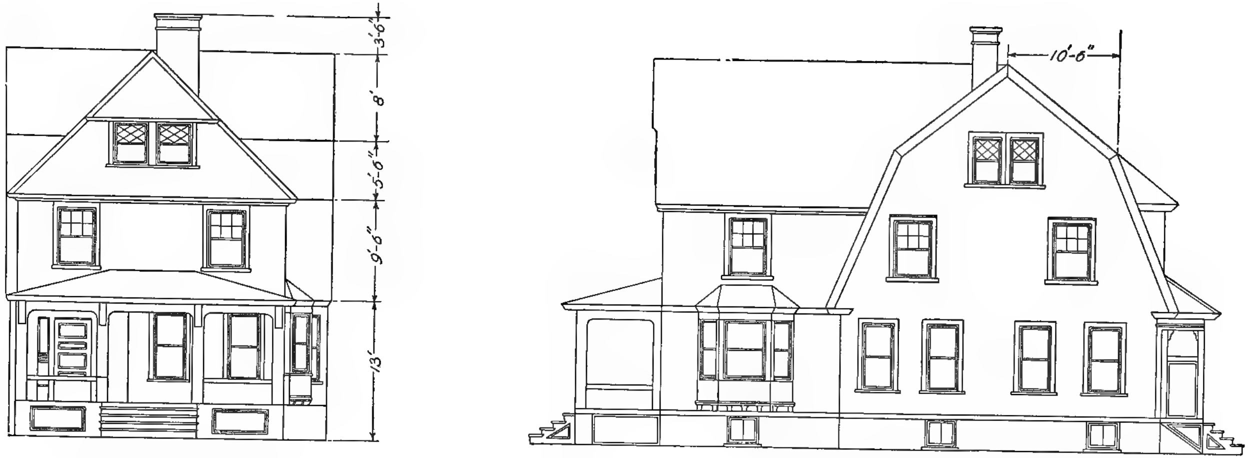

ROOF PLAN
3'-3"
SECOND STORY PLAN
11'
3'
3'-6"
10'
5'-6"
27'
12'
FIRST STORY PLAN
17'
9'
5'
4'
8'
9'
10'
6'-6"
2'-6"
11'-6"
10'-6"
4'-6"
3'-6"

FIG. 61



FRONT ELEVATION

SIDE ELEVATION

Fig. 62

In a similar manner, other points may be located for the window on the side, and the details of the windows projected in the perspective elevation. The completion of the elevation consists simply in laying off the proper heights and proportions of these details on the measuring line $a x$, and taking their perspective widths from the projection of the plan.

PROBLEM VIII

76. In Fig. 61 is shown another set of plans for a simple house, the roof of which is of a different type, as shown in Fig. 62, and requires more careful study in the location of its different points. Fig. 63 shows the rendering of this house in perspective, as well as its appearance when the perspective sketch is complete. The construction lines in the plan are all left in place, and a comparison of the dimensions with Fig. 61 will show the purpose of each. The corner of the building is used as a line of measures in the elevation, and is in contact with the line of measures in the perspective plan. This brings the porch and steps in front of the line of measures in the plan without complicating the problem or rendering it difficult to carry out. Fig. 64 illustrates the shading of the perspective after the sketch has been worked out in pencil according to the perspective measurements.

PROBLEM IX

77. It is sometimes necessary and desirable to render a building somewhat more rustically than the foregoing, or to use perspective drawing in connection with a subject that is more pictorial in character. In Fig. 65 is shown a photographic illustration of the Parthenon, at Athens, in its ruined condition. To reproduce this on a larger scale in perspective, it is first necessary to draw a plan, such as is shown in Fig. 66, where all the details of the building are expressed without indication of ruin. Use scale $\frac{1}{16}'' = 1'$. This plan, or its dimensions, can be used in laying out a perspective plan, such as is shown in Fig. 67, and from the perspective plan the perspective elevation can be projected in its completed condition,

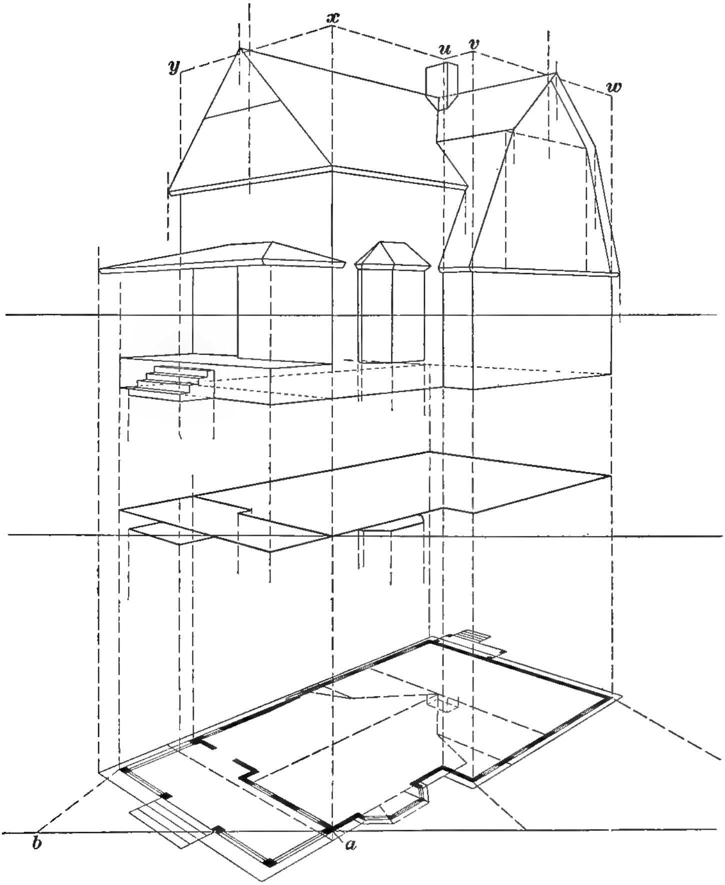


FIG. 63

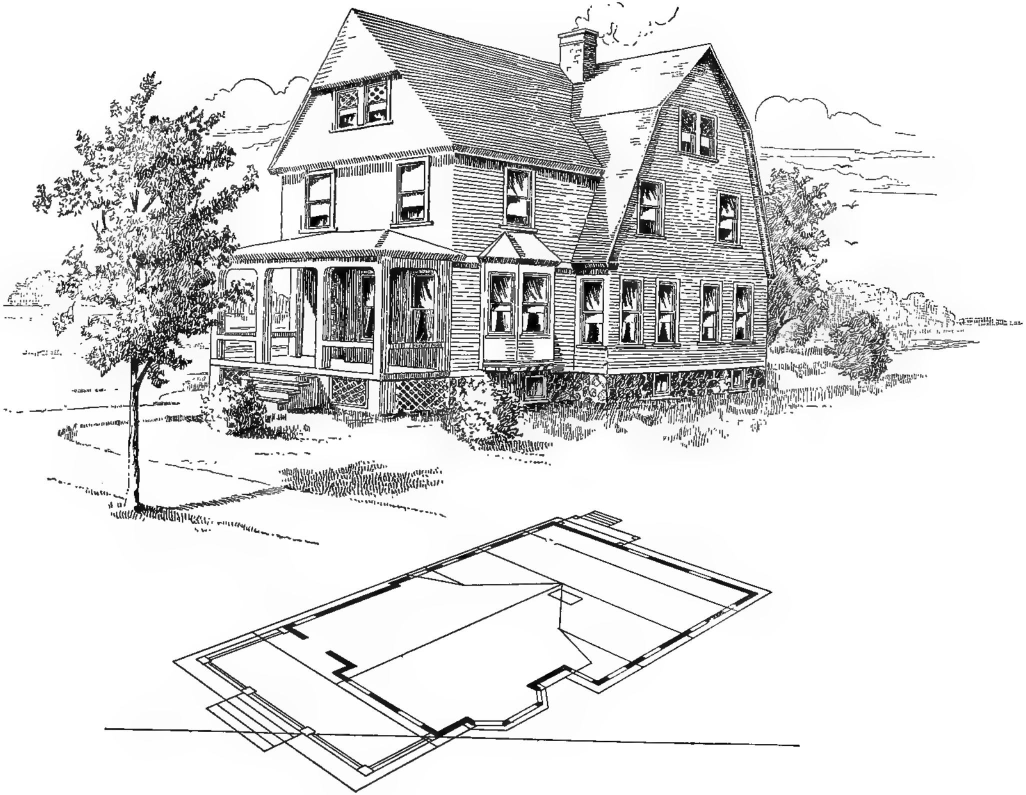


FIG. 64

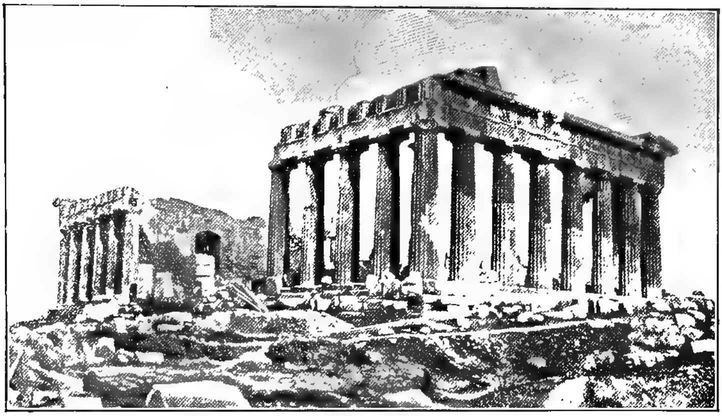


FIG. 65

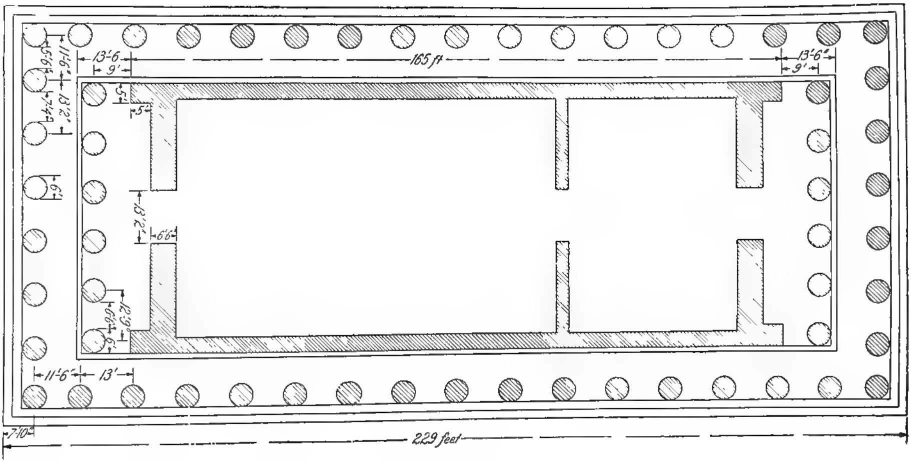

13'-6"
9'
165 ft
13'-6"
9'
11'6"
5'6"
7'4"
13'2"
6'
5'
5'
18'2"
6'6"
12'9"
6'6"
6'
11'-6"
13'
7'10"
229 feet

FIG. 66

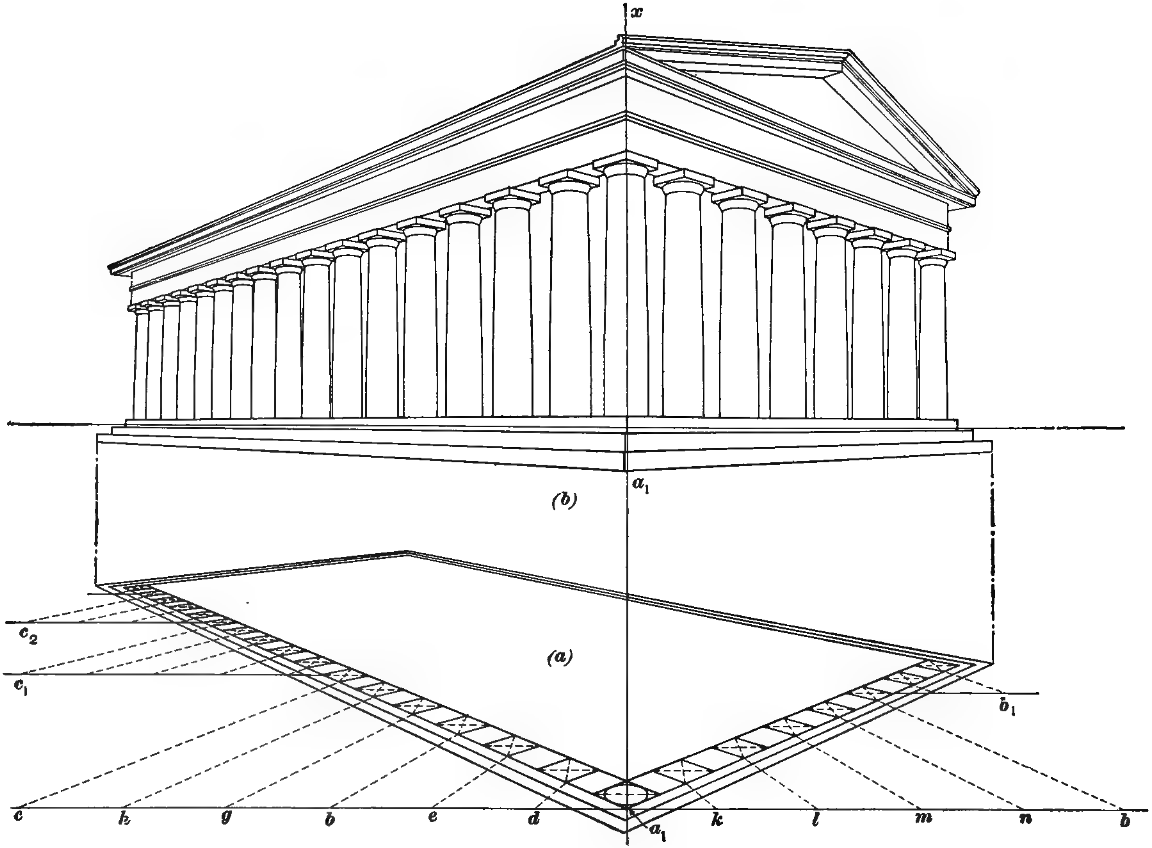


FIG. 67

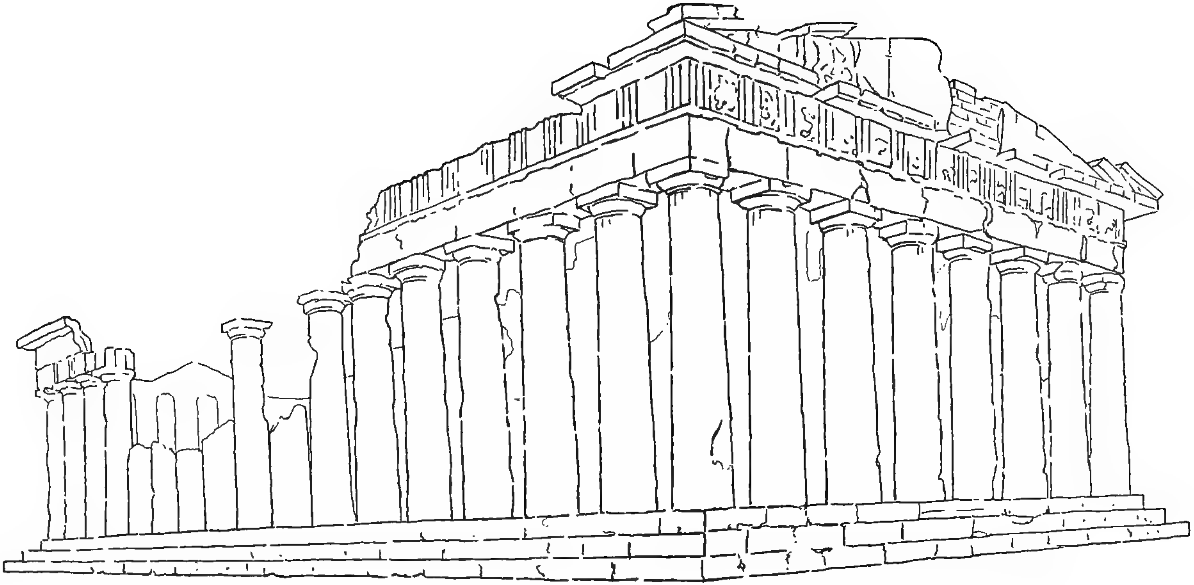


FIG. 68

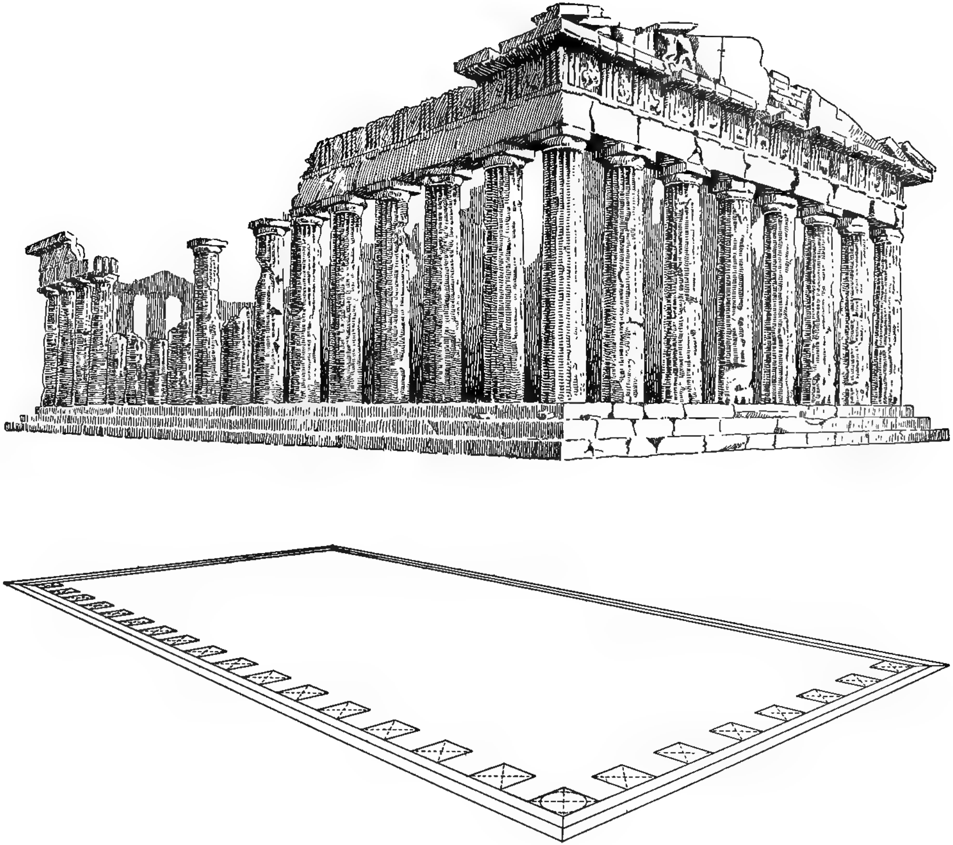


FIG. 69

as shown. It is not necessary that the ellipses representing the plans of the columns be worked out entirely, as a straight line representing the diameter of the column at the bottom is all that is necessary. The rest can be done by eye measurement, and when the perspective elevation is completed, as shown in Fig. 67, the removal of certain portions to represent its ruined condition and the treatment of the details can be carried out in outline, as shown in Fig. 68. The drawing in this condition is ready to ink in for a pen-and-ink study, as in Fig. 69, to color in for a water-color study, or to shade up in pencil for a finished pencil study, but in any drawing it is necessary first to complete the perspective in outline to show the general conditions.

78. In the foregoing examples, it was necessary only to sketch in freehand the outlines of the capitals and moldings of this architectural subject, but occasions may arise where these details are so large that it is desirable to work them

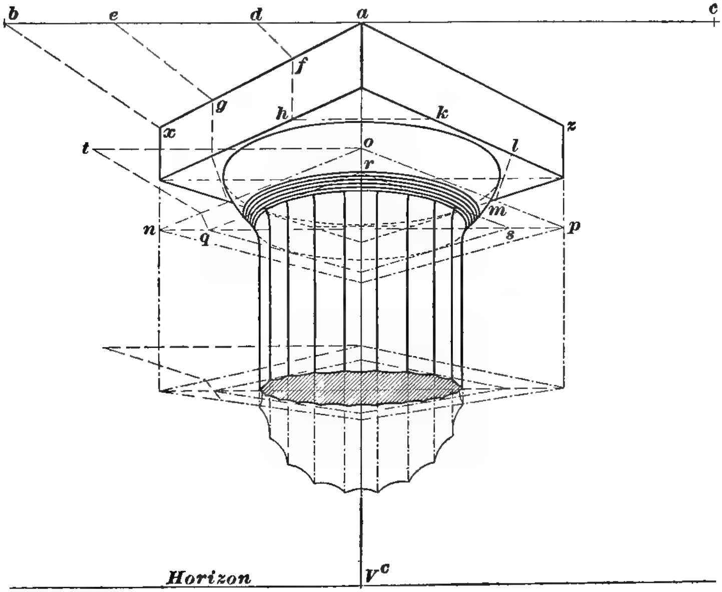


FIG. 70

out with greater accuracy. In Fig. 70 is shown the Doric capital and the method of getting its proper perspective.

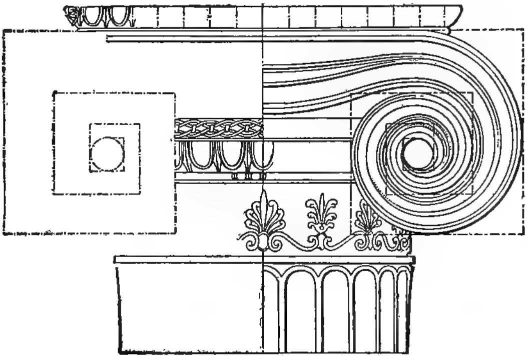


FIG. 71

The measuring line *b a c* is drawn at any convenient point above the horizon, and the measurements of the details of

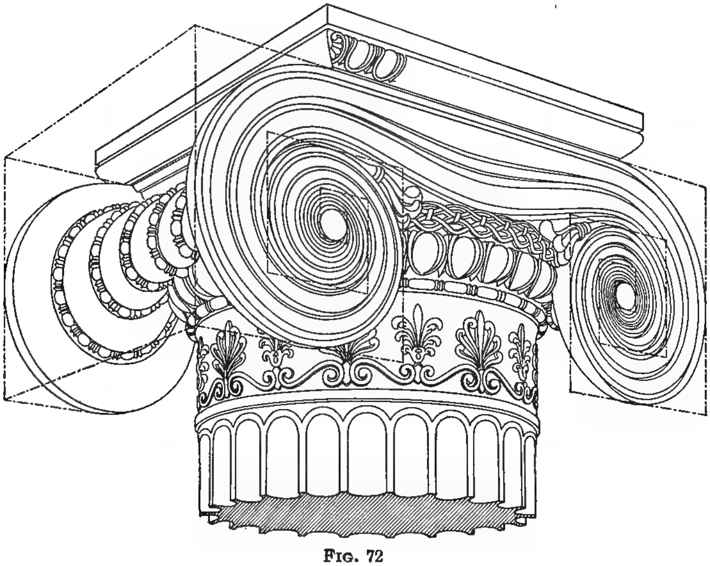


FIG. 72

the capital laid off from *a* toward *b* and *c*, the distances *a b* and *a c* each being equal to the side of the abacus, and the intermediate distances being laid off to determine the sizes of the smaller squares within which circular annulets are drawn. The flutes on the column may be projected from the perspective plan of a regular sixteen-sided figure if it is so desired, but for all practical purposes a circle may be drawn and divided into the required number of parts, and these parts projected directly. The latter method is not strictly accurate but is sufficiently so for all practical purposes.

79. In drawing the Ionic capital, vertical curves are called into existence. The diagram, or volute, is laid out in its proper proportions, first, by straight lines, as shown in Fig. 71. This form is then drawn in perspective, as shown in Fig. 72, and the scroll sketched in freehand.

The Ionic base is not easy to express accurately in perspective. The best way to do it is to make a perspective drawing of the plinth, either in 45° perspective, as in Fig. 73,

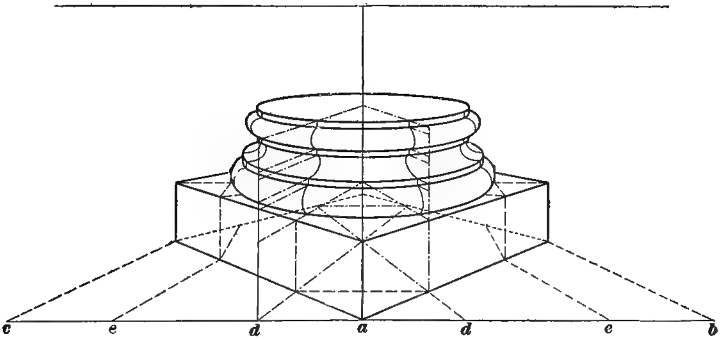


FIG. 73

or in parallel perspective, as in Fig. 74. In the latter, only one side of the plinth and a portion of the top are seen, while in Fig. 73 two sides and a portion of the top are visible. The top of this plinth should be divided so as to represent an octagon in perspective, and on the diagonals of this octagon perspective views of the profiles of the base, as shown in Fig. 75, should be drawn. First, draw the elevation of the profile of the base, as in Fig. 75; then, draw the perspective of this profile in different positions, as in Fig. 74. Thus, when profiles extending from *a* to *o*, *b* to *o*, *c* to *o*, and *d* to *o* are drawn, they can be united by carefully sketched curved lines, as in Fig. 73, so as to present a full perspective of the base. In making perspective drawings of circles, it is always best to consider them as exactly in the center of vision, for when they are moved far to the right or left, they are likely to become distorted unless the drawing is so held that the object shown appears at its

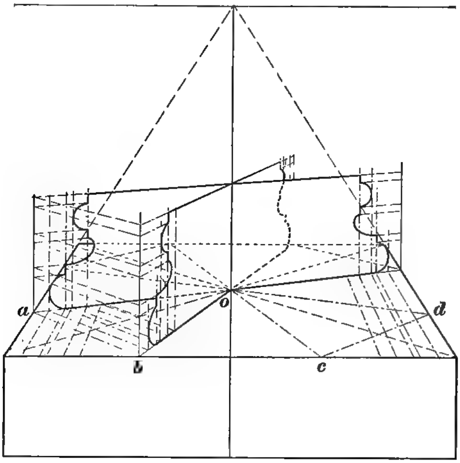


Fig. 74

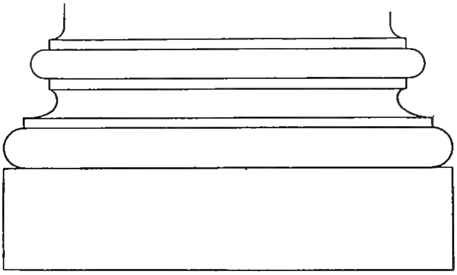


Fig. 75

proper distance to the right or left of the eye. Thus, in Fig. 76, the Doric capital looks very much out of proportion, owing to its being placed so far to the left, whereas if the circular portion of it, or top member, had been drawn as in its previous illustration, Fig. 70, this difficulty would be entirely obviated.

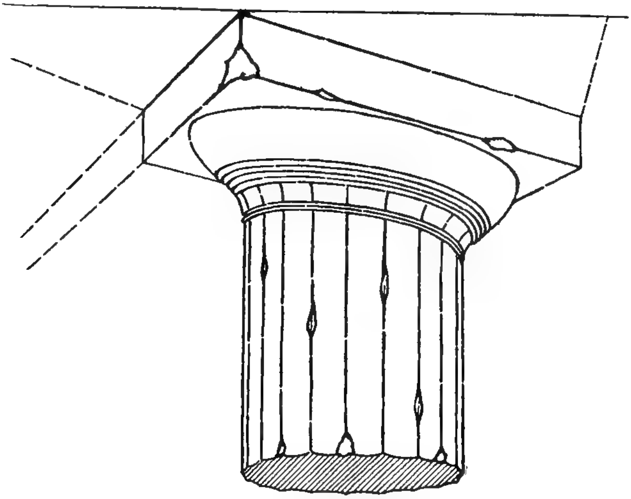


FIG. 76

In Fig. 77 is shown an Ionic base, the plinth of which shows that the detail is far to the left of the center of vision. The moldings, however, are drawn as though the base were directly in front of the eye, thus preventing all appearances of distortion.

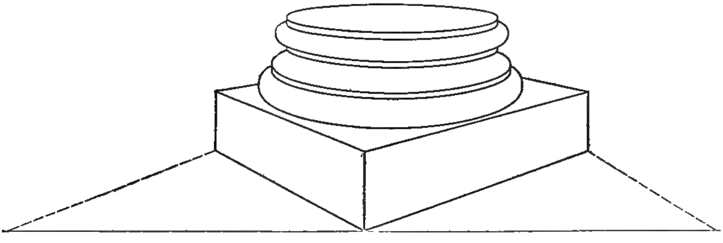


FIG. 77

Fragmentary pieces of columns can be drawn in perspective in either position with little regard to the general appearance of the polygons forming their tops, as these are likely to appear with broken edges, and the irregularity compensates what would otherwise be a distortion, as in Fig. 78.

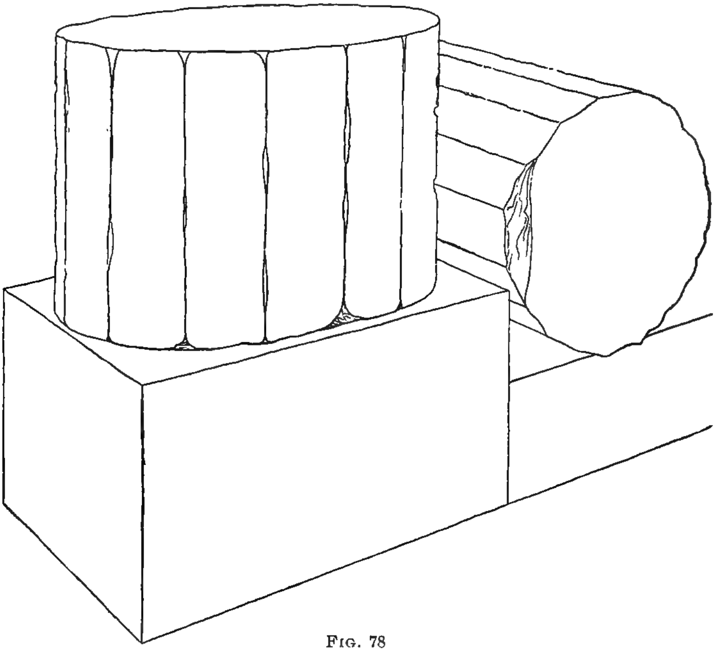
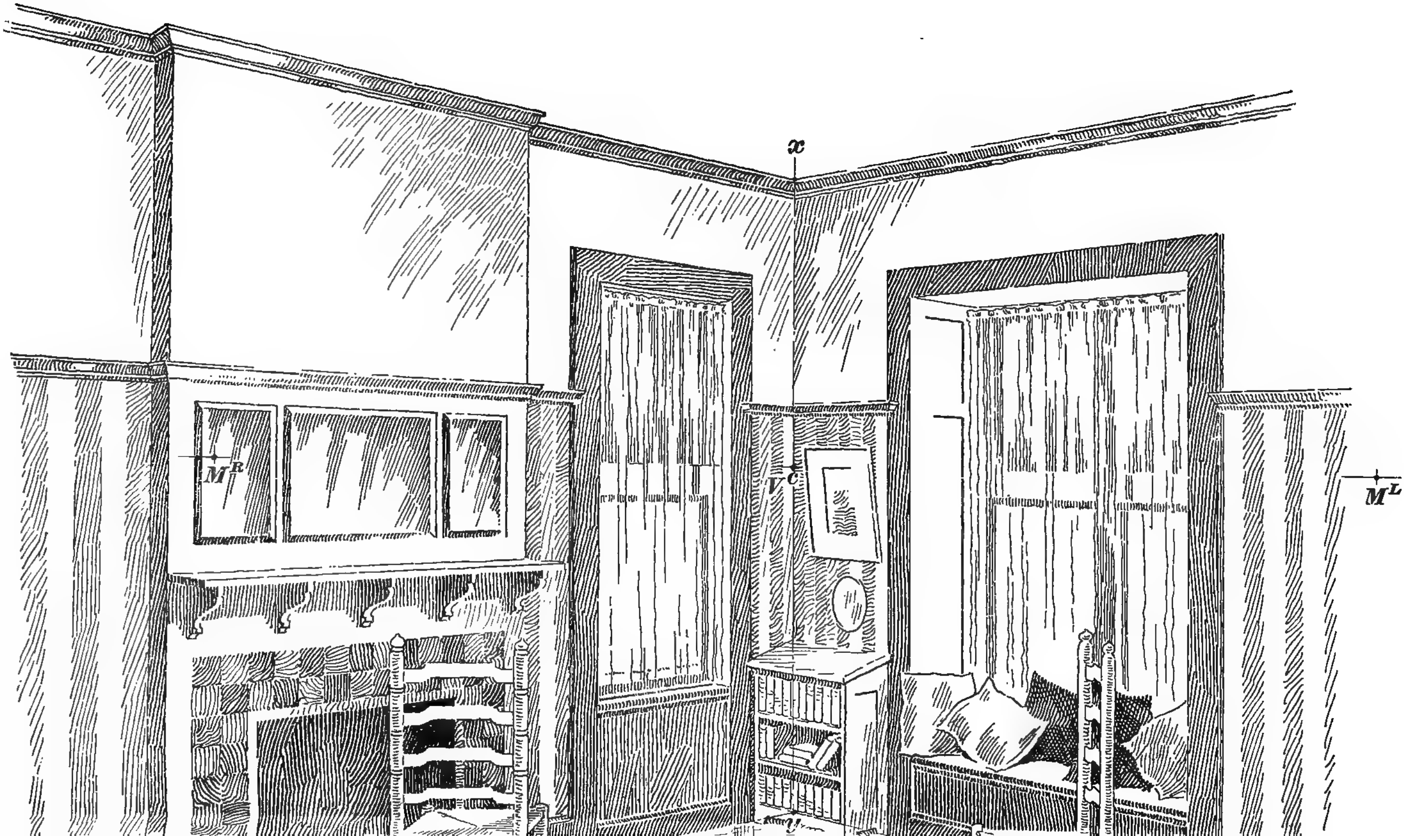


FIG. 78

PROBLEM X

80. Up to the present time, all the examples illustrated have been exteriors showing plans of buildings viewed from the outside. A problem of an interior showing the details of a room will now be taken up. In Fig. 79 are shown the plan and two elevations of a small room on which are indicated three pieces of furniture, one a bookcase, similar to that illustrated in Art. **71**, and two chairs similar to that illustrated in Art. **72**, the difference being that while the room is in 45° perspective the chairs are in parallel


x
M^R
V
C
M^L
y

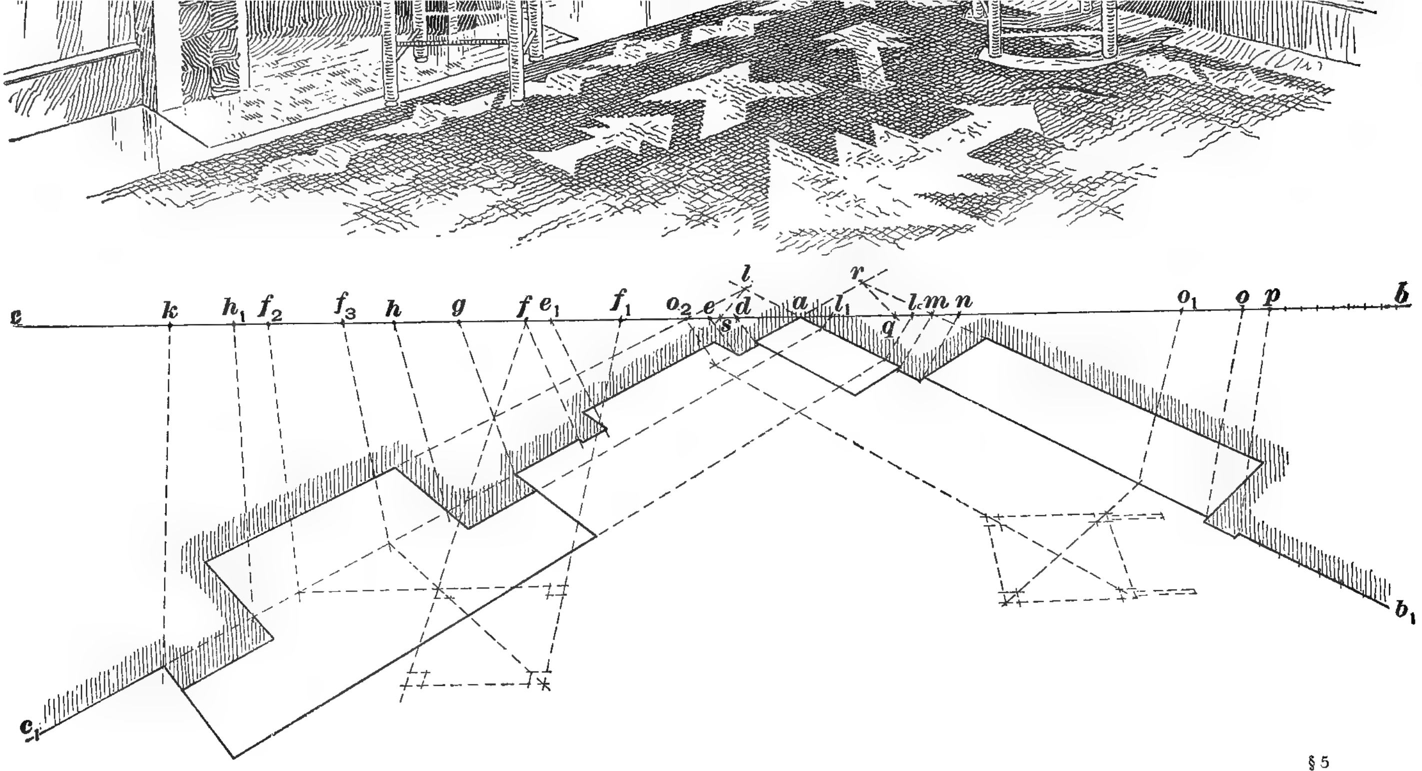


FIG. 80

perspective. In this case, the measuring line ab, Fig. 80, is laid off for dimensions on the right side of the room, and ac for dimensions on the left side. It will be observed that the entire plan is in front of or below the measuring line in this case, and on the line that vanishes at V^L the measurements laid off on it are from the measuring point M^L; and, on the contrary, the measurements laid off on ac are projected into the perspective plan from M^R because ac vanishes at V^R. The line ax going through the corner of the room serves as a measuring line on which all the details are laid off to scale, and are projected therefrom to their proper position in the sides of the room. It is evident from this that the details of the room will be larger than their scaled dimensions. A scale of $\frac{3}{8}'' = 1'$ may be used.

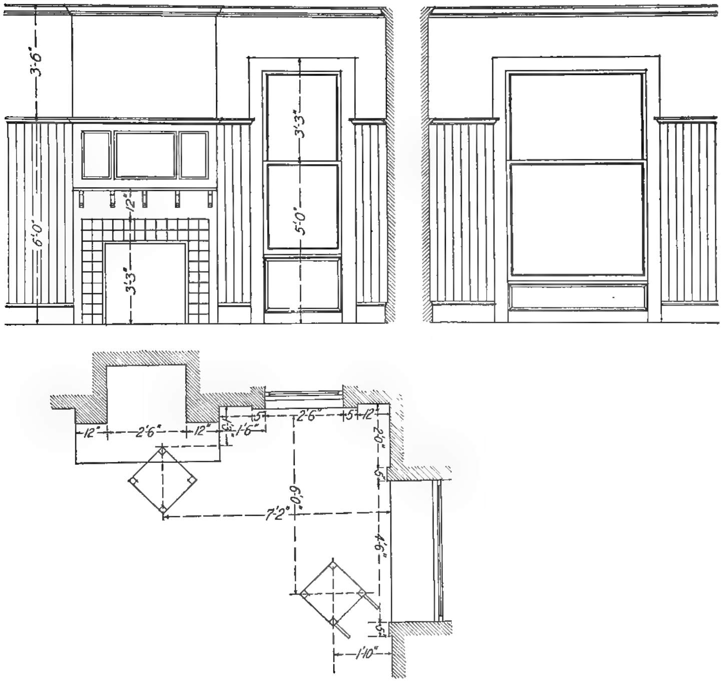


FIG. 79

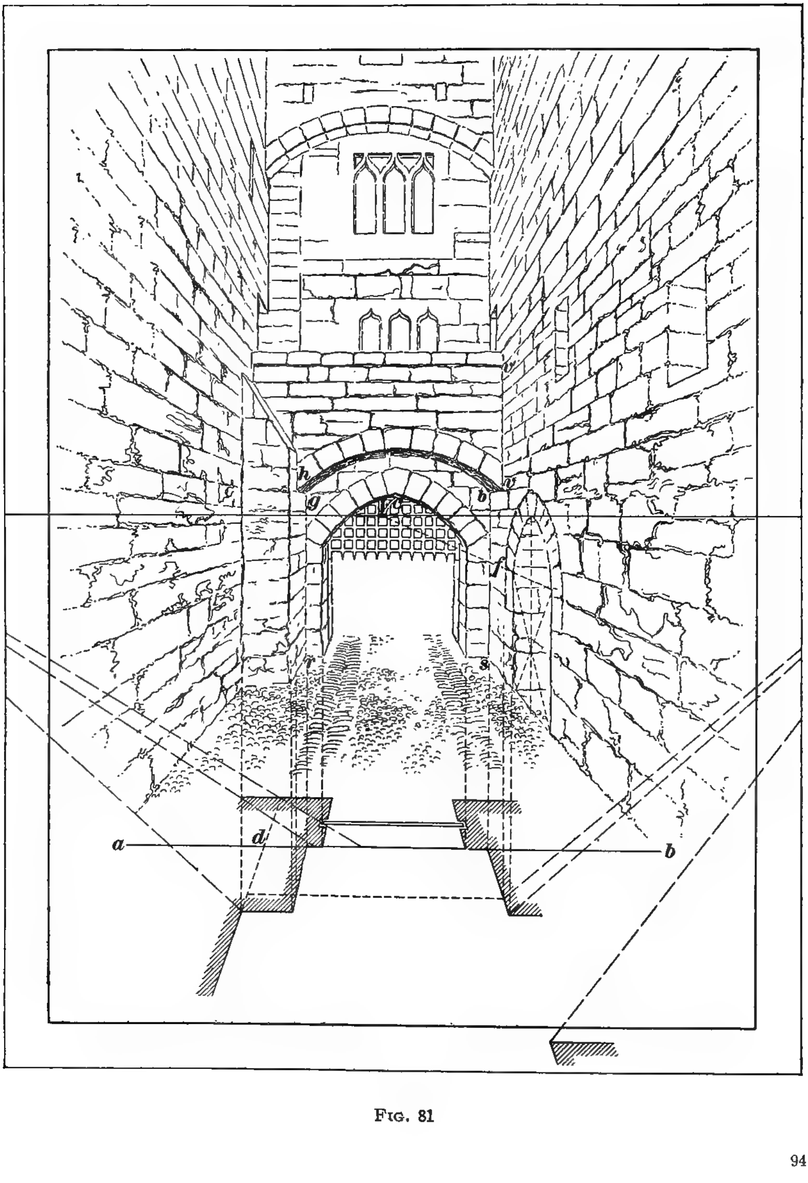


FIG. 81

PROBLEM XI

81. The problem shown in Fig. 81 is the perspective rendering of a view of the entrance gate or portcullis of Warwick Castle, England, a photograph of which is shown in Fig. 82.

82. This drawing is to be executed on the usual sheet 9 inches by 12 inches, but the vanishing points V^L and V^R will be located to the left and right of the sheet, as was illustrated in Fig. 52. The plan of the entrance and elevation of the end wall are shown in Fig. 83, and the problem is to be drawn in parallel perspective with the measuring line *a b* placed as shown in the plan and located in the perspective drawing about 2½ inches above the lower edge of the sheet. The point *d*, Fig. 81, will be located on this line $2\frac{15}{16}$ inches from the left edge of the sheet. The horizon line should be about 6¼ inches above the lower edge of the sheet, and the vanishing points V^L and V^R 13 inches apart, the center of vision V^C being 4¾ inches to the left of the edge of the paper. All the measurements of the plan should be laid out on the measuring line *a b* at a scale of ⅛ inch equals 1 foot, and transferred to the main lines of the plan which vanish at V^C, by means of the points V^L and V^R, as was explained previously under the heading Parallel Perspective. After the plan is complete, the various points may be projected to the perspective elevation, and the heights in the elevation can be laid out according to the measurements given in Fig. 83. The ground line *r s* is exactly 13 feet below the horizon and the door in the side wall is also 13 feet high to the top of the arch and 8 feet from *s* to *f*. The center of the gateway should be located according to the ⅛-inch scale, 1½ feet to the right of the center of vision, and through this last point a vertical line should be drawn from which the centers of the arches can be located. As shown in Fig. 83, these centers are 2 feet 6 inches apart, and equally spaced each side of the center line of the opening, and are 6 feet 6 inches below the horizon line; therefore, a horizontal line should be drawn 6 feet

6 inches below V^L–V^R on which these centers are located 1 foot 3 inches each side of the center line of the opening.

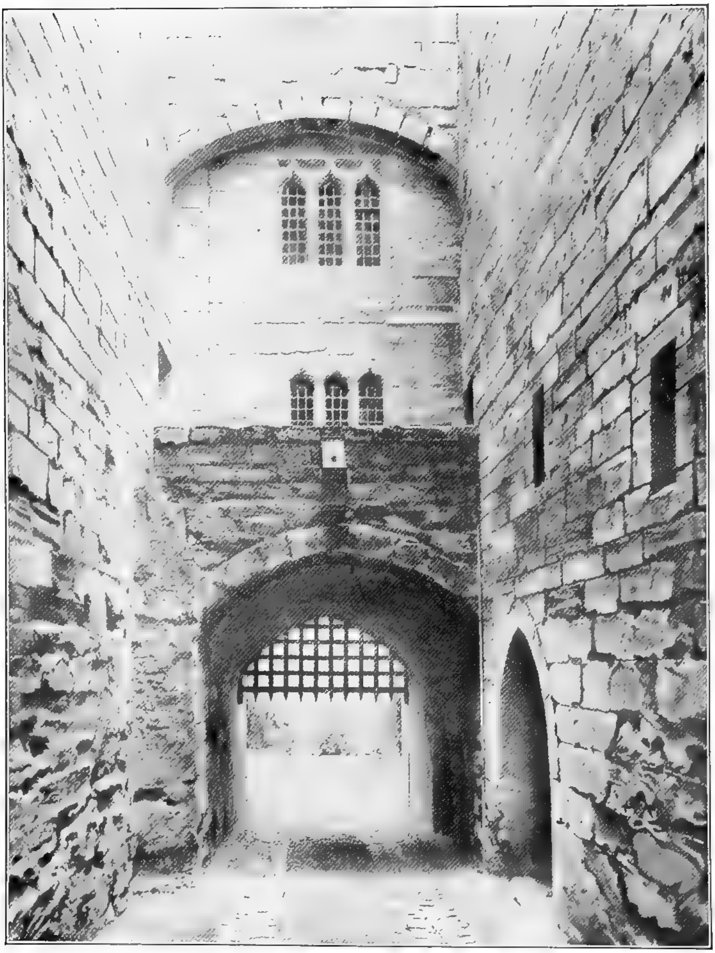


FIG. 82

With the radius 8 feet 6 inches and the points so located as centers, the arcs may be drawn for the under side of the arched opening, and by lengthening the radius 2 feet the

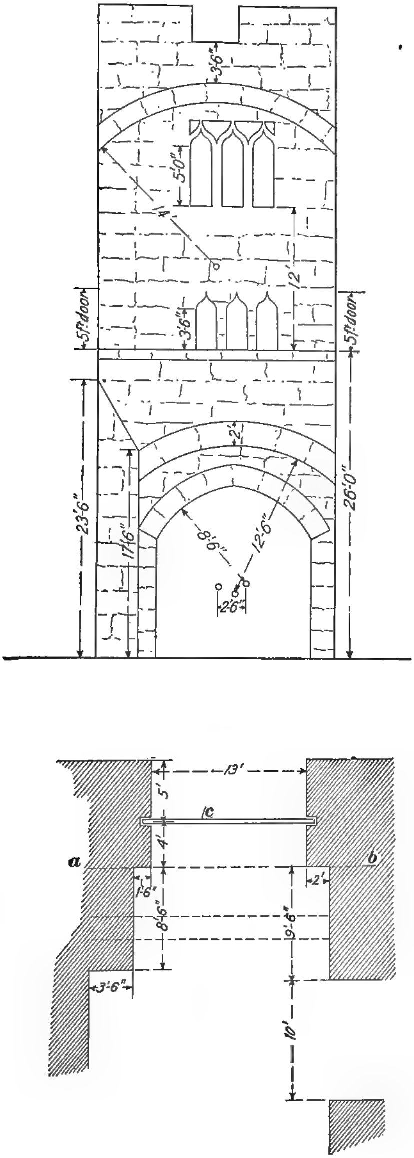


FIG. 83

outer arcs may be drawn. Now, with a point on a center line between bs and rg, and 7 feet 6 inches below the horizon, another arc should be drawn with a radius of 12 feet 6 inches showing the lower curve g–b of the arch supporting the gallery wall. This arch, however, projects somewhat and it is necessary to get the location of the lines limiting this projection. So, from the corner of the right-hand pier in the plan, lay off on ab to the right a distance of 6 feet 6 inches, marking the projection of the gallery wall. Through this point draw from V^R a line to intersect the line from the corner of the pier to V^C, which will be the right-hand edge of the gallery projection, and is shown by the vertical line vv' in the elevation. A line from V^C through b will locate v, which will be the end of the curve of the supporting arch. Since this arch projects from the picture plane, its center must be projected to a vertical line erected midway between the points *v* and *h*, by means of a line drawn through V^C. With this new center, which will be about 9 feet 6 inches below the horizon and about 2 feet to the right of V^C, another arc is struck from *v* to intersect with a line projected from V^C through *g*. The voussoirs on the arches are 2 feet deep, and the radiating lines between them are drawn toward the centers from which each arc is struck.

When laying out the vertical measurements of the gallery wall and buttress, it should be borne in mind that these are in advance of the picture plane and measuring line *a b*, and that their heights must be projected from that plane by means of lines drawn through V^C. Thus, 17 feet 6 inches and 23 feet 6 inches, the heights of the front and back edges of the buttress, are measured on a vertical line projected above *r*, Fig. 81, and through the points so located lines are drawn from V^C to meet the edge of the buttress in contact with the wall on a line projected above *h*. In the same manner, the height of the gallery wall 26 feet is measured on the vertical line *s b* prolonged to the lower curve of the upper arch in the elevation, and is projected to the line *v v′* from V^C.

The two windows in the side wall are 16 feet 6 inches and 24 feet 6 inches from the picture plane and 3 feet and 4 feet wide, respectively. Their relative positions may be ascertained with sufficient accuracy after the courses of stone are laid out. The upper portion of the structural work over the entrance is in contact with the picture plane and can be drawn directly to scale, as was the gateway.

The radius for the projecting arch over the upper set of windows, as shown in Fig. 83, is 14 feet, and the center of this arch is midway between the two walls and 20 feet 6 inches above the horizon. The amount of the projection is 1 foot 6 inches and it may be laid out on the measuring line and transferred to the perspective drawing, as was previously explained regarding the arch supporting the gallery wall.

ARCHITECTURAL DRAWING

INTRODUCTION

1. Architectural drawing does not consist simply of the drawing of architectural objects; it is, in itself, a kind of drawing separate and distinct from mechanical drawing—whether the object represented is architectural or not. The essential difference between architectural and mechanical drawing is due to the expression of the individuality of the draftsman, architectural renderings being much freer and less restricted than mechanical representations without, on that account, being any the less accurate. This difference in feeling is acquired by degrees, as the draftsman proceeds in his studies and practice, and is due largely to the difference in the materials used.

The mechanical draftsman uses a very hard pencil and a smooth paper, on which he represents his objects with thin, hard, wiry lines united by equally wiry arcs struck with the compasses or with the irregular curve. It is purely outline drawing with instruments; no freehand representations enter into this work; in fact, the natural broadness of freehand work would be out of place entirely in mechanical representations.

The skilled architectural draftsman does not use a pencil harder than HB, the point of which he sharpens frequently. As rough paper is used, the soft pencil soon dulls and the draftsman's lines vary in weight, color, and texture as his work proceeds. His curves are in many cases simply

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freehand touches, and the straight lines that unite them rarely stop exactly at the point of tangency, but frequently stop short of it; and in the case of two straight lines intersecting at an angle, they run past each other. This is characteristic of all architectural drawing, and instances will be pointed out as these instructions proceed. The mechanical draftsman deals with outlines from which accurate measurements may be scaled, while the architectural draftsman deals entirely with masses and employs his outlines simply to limit these masses.

The mind of the architectural draftsman is on the beauty of the structure that he is creating for a utilitarian purpose, and his method of representing that structure—whether it is in plan or elevation—naturally partakes, to some extent, of the feeling that impels the draftsman to his work. The mechanical draftsman, however, is working a design for a purely utilitarian purpose; back of it there are no thoughts of art nor beauty, and rarely more than careful considerations for economy of material combined with strength.

2. Finished architectural drawings are seldom inked on the paper on which the original plans are worked out. Instead of this, the sheet is traced on cloth, and from the tracing thus made blueprints are produced that serve as actual working plans for the mechanic. As these original drawings are not used for any purpose other than the basis for the tracing, they are not executed on a fine quality of drawing paper, but are usually drawn on Manila or some other cheap paper that will stand erasing and serve as an office copy for reference. This Manila drawing paper is usually called **detail paper.**

The drawings executed as hereafter directed should be made on a brown detail paper similar to that on which some of the exercises are printed in the Instruction Paper. These printed exercises are not furnished as copies, however, but simply as guides to illustrate how the work is to be done. The exercises should be executed according to the printed instructions for each problem, and the application of such principles, as they arise, that have been explained in connection with previous problems.

While each of the exercises that follow is a problem in itself, the entire set of plans and details, with their necessary tracings, constitute a collective problem that is intended to cover all the principles taught in this Section.

MATERIALS AND METHODS

3. It is the intention here to give practical instruction in architectural drawing just as it would be received in the *atelier*, or working room, of some practicing architect. The instruments used in geometrical drawing are all that are required in architectural drawing. Additional devices in the form of measuring strips will sometimes be found useful, and softer pencils (B or 2B) than HB should be used for making preliminary sketches.

As all plans of buildings are drawn much smaller than the finished building is to be, a system of **scales** is used, so as to proportion the plan to the building, and all drawings for architectural purposes are *made to scale*, whether the scale is $\frac{1}{4}$ inch to the foot, $\frac{1}{2}$ inch to the foot, or full size of the original object (the term "made to scale" signifying that the drawing can be measured exactly). The scale used for thus proportioning the plan is usually a flat strip of wood with beveled edges carefully graduated into inches and fractions of an inch, each of which represents 1 foot in the proposed proportion. When a drawing is made full size, the scale is divided into inches and fractions of an inch; and when it is made half size, the subdivisions of the scale are numbered consecutively as though each $\frac{1}{2}$ inch were an inch.

4. Plans for buildings are usually laid out at $\frac{1}{4}$ inch to the foot, and preliminary sketches are laid out on a scale of $\frac{1}{8}$ inch or $\frac{1}{16}$ inch to the foot; that is to say, each eighth or sixteenth on the drawing represents 1 foot in the finished building.

The scale of $\frac{1}{4}$ inch to the foot consists of a series of $\frac{1}{4}$-inch subdivisions numbered from *0* upwards, as shown in Fig. 1.

The first subdivision below the zero mark is divided into twelve parts to represent inches; therefore, in laying out a distance of 4 feet 4 inches, the scale is laid with the 4-foot mark at one end of the distance to be laid off, and the 4-inch mark beyond the zero point at the other end. In scaling a measurement on a plan to determine how great the measurement is, the zero point is placed at one end of the distance, and then the scale is slid to the left sufficiently to bring one of its subdivisions of feet at the other end of the distance to be measured. Beyond the zero point the number of inches can easily be read off. Where it is necessary to duplicate a plan or to transfer partitions or other details from one plan to another, a measuring strip consisting of a piece of paper about ½ inch wide and a foot or more in length can be conveniently used. The measuring strip is laid across the plan and held in place with the fingers, while the positions of partitions, fireplaces, chimneys, stairs, doorways, or any other desired details can be marked on the edge with pencil. The measuring strip can then be transferred to the other plan, and these details marked on the other plan exactly.

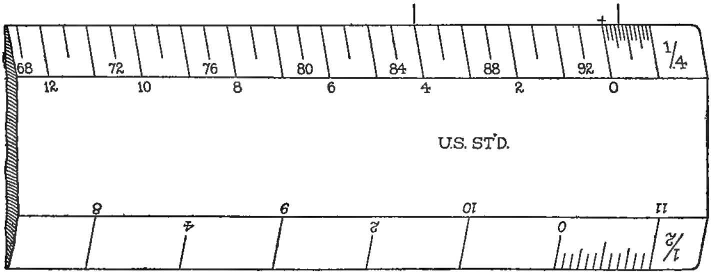


FIG. 1

EXERCISES

MOLDINGS

5. In all architectural work, angles formed by the intersection of two planes are usually ornamented by a series of flat and curved surfaces called **moldings.** Instead of letting the edge of a slab of wood or stone that forms the top of a structure remain perfectly square, its angles are usually decorated with a series of ornamental cuttings that combine to form a molded edge. These moldings have various names—according to their curvatures—and their surfaces are either perfectly plain or enriched by carving. The cross-section of a molding showing its actual outline is called its *profile.* A perfectly plain vertical surface projecting beyond another surface is called a *band* or a *face;* or, a *fascia* if the surface is wide and a *fillet* when the surface is narrow, as shown in Fig. 2 (*a*).

6. Names of Moldings.—A simple convex molding is called an *ovolo*, or a *quarter round*, when its profile presents one-quarter of a circle, ellipse, etc., as shown in Fig. 2 (*b*). It is called a *torus* when its profile presents one-half of a circle or ellipse, as shown at (*c*); and a *three-quarter round* when its form is as shown at (*d*). A very small convex molding, as at (*e*), is called a *bead* or *astragal*, and an elliptic form of the torus molding, as at (*f*), is sometimes called a *thumb molding.*

The concave moldings are the *cavetto*, at (*g*), and the *scotia*, at (*h*); their forms correspond closely to the reverse of the ovolo and the torus. In combining a convex and a concave molding, another series, called *cymas* or *wave moldings* is produced. These are divided into two kinds: the *cyma recta*, as at (*i*), sometimes referred to as a *Crown molding*, owing to the fact that it is used principally at the top of a structure, and the *cyma reversa*, as at (*j*), often called an *ogee molding.*

7. All the moldings just described were used by the ancient Greek and Roman architects, and are therefore termed **classic moldings,** but there is a decided difference between the Greek and Roman profiles of moldings bearing the same names. The profiles of the Greek moldings usually approached in their contour the curve of some conic section. They were probably designed freehand, but their profiles in nearly every instance partake of the curvature of the ellipse,

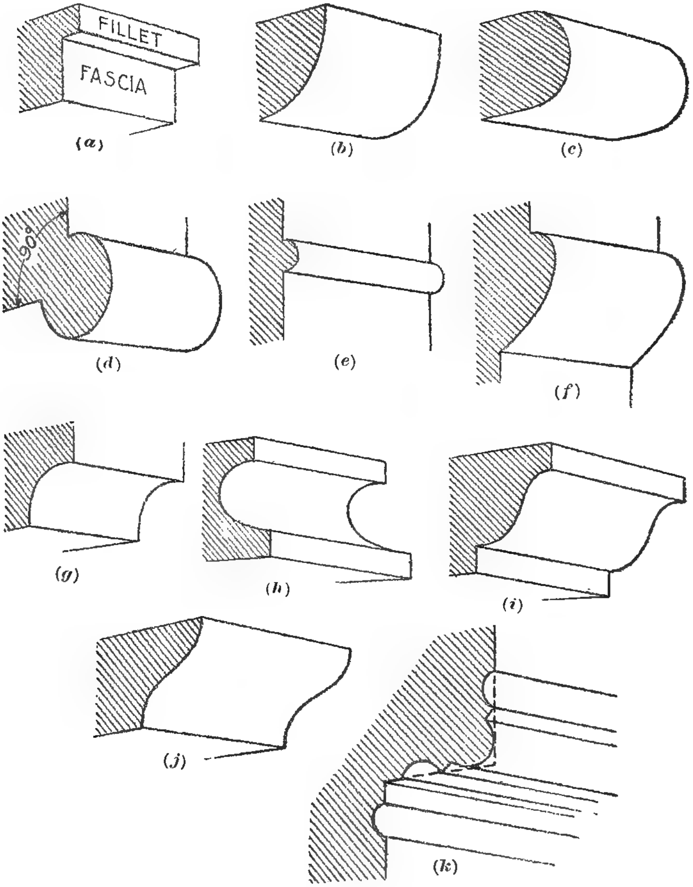


Fig. 2

the parabola, the hyperbola, or a combination of these curves, whereas, the Roman moldings were nearly always arcs of circles. There is a hard monotony about the curvature of the Roman moldings that never exists in Greek moldings. Moldings contoured freehand are always to be preferred to those that are struck with the compasses.

Besides the foregoing, there are additional molded forms that were used by the architects of the middle ages, and these are usually termed **Gothic moldings.** They were worked on the external angles formed by two planes, as in Fig. 2 (*k*), and were cut in and lay below the surfaces of both planes, in contrast to the classic moldings, which project beyond the plane of the surfaces. Different systems of construction have produced various styles of moldings, and different periods of civilization have adopted or borrowed the styles of other periods to suit their conveniences. Thus, at the present day, while both the Gothic and classic moldings are still used, the Oriental details of architecture have never found practical use in modern building.

EXERCISE I, TITLE: CLASSIC MOLDINGS

8. In Exercise I, which consists of two sheets, will be drawn the five principal classic moldings, with their characteristic Greek and Roman profiles, together with four examples of these moldings enriched with the usual surface ornament that is used with each. These moldings should be drawn 1″ wide and $2\frac{5}{8}$″ long on Sheet I, and should be spaced 1″ apart and $\frac{5}{8}$″ above the lower border line, thus leaving a space $1\frac{3}{8}$″ wide at the top of the plate for the title.

Each molding is shown between two fillets, as fillets are frequently used to separate different members of a group of moldings. They are made from one-third to one-eighth the height of the molding for the sake of simplicity in drawing, but in actual architectural practice the proportion varies more than this.

9. Exercise I, Sheet I.—Commence Sheet I by drawing the 8″ × 11″ border lines as usual; then draw a series of horizontal lines entirely across the plate, the first line to be $\frac{5}{8}''$ above the lower border, and the second, 1″ above the first. These two lines will represent the upper and lower edges of the lowest molding. A space of 1″ should now be left, and another line drawn representing the bottom of the second row of moldings, and so on until all the moldings are located. After this, draw four vertical lines through the plate, locating them 1″ inside of each vertical border line and $\frac{3}{8}''$ each side of the vertical center line. The width and length of each of the ten sections of molding will then be fixed.

Draw the two fillets of the moldings $\frac{1}{8}''$ each, as shown, and with the 45° triangle draw a light line *a b* from the lower corner of the upper fillet to the upper corner of the lower fillet for the cyma recta, thus marking the end of the lower fillet. Then carefully sketch in freehand the subtile curve of the Greek cyma recta. Note that the profile of this molding curves abruptly from the top and bottom fillets and gradually approaches a straight line in the middle, *but it does not become perfectly straight between any two points.*

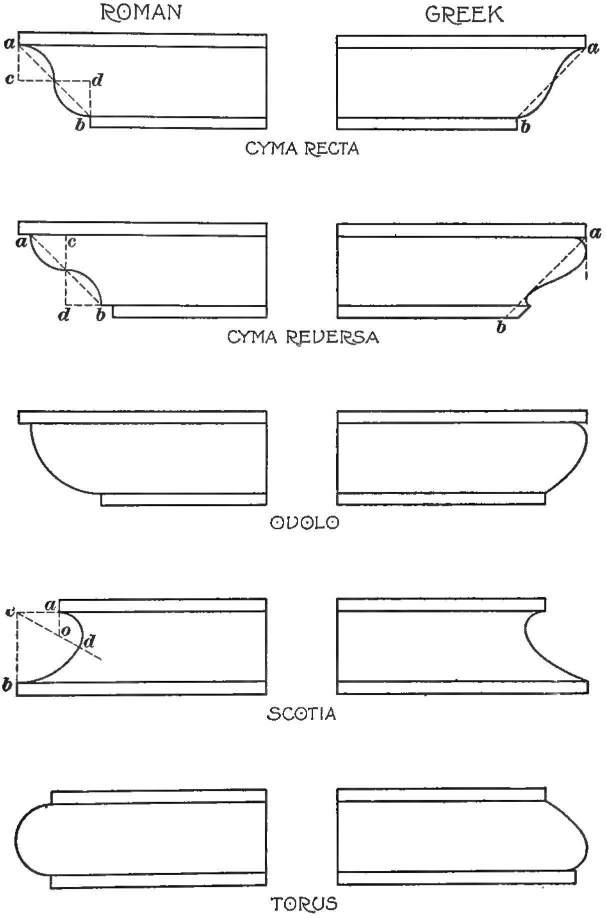
Now proceed with the Roman cyma recta. Bisect the diagonal *a b* on this molding and draw a horizontal line *c d*. Erect perpendiculars through *a* and *b*, intersecting *c d*, and with the points of intersection as centers, draw the two quarter circles that unite to form the curve of this molding.

10. To contour the Greek cyma reversa, draw a diagonal *a b* as with the cyma recta, and profile the molding freehand, starting the curve about $\frac{3}{16}''$ to the left of the end of the upper fillet and bringing it out tangent with the line limiting all the molding. Note that the curve of this profile becomes tangent to the diagonal *a b* and then swings out and intersects the lower fillet about $\frac{1}{4}''$ to the right of *b*. The end of the fillet is then cut off at an angle of 45° as shown.

The Roman form of the cyma reversa is contoured in exactly the same manner as the Roman cyma recta. The point *a*, however, is $\frac{1}{8}''$ to the right of the end of the fillet, but the line *a b* is drawn and bisected as before; the line *c d* is drawn vertically through the center, and horizontal lines

Exercise I *Title* *Sheet I*

CLASSIC MOLDINGS



Date

Time consumed in executing this sheet

Name of Student, Class Letters and Number

are also drawn through *a* and *b*. The centers for the two quarter circles forming this profile are located on the inside lines of the fillets directly opposite *a* and *b*. The lower fillet does not reach to the point *b* but stops $\frac{1}{8}''$ from it.

11. In drawing the ovolo, or quarter round, no diagonal construction line is necessary. The upper and lower fillets are both $\frac{1}{8}''$ wide, and the latter is $\frac{7}{16}''$ shorter than the former. The curve of the Greek ovolo is rather abrupt at the start, but gradually flattens out until it intersects the lower fillet at its upper angle. This curve is very similar in outline to an egg, to which, in fact, it owes its name.

It is from the Roman form of this molding that the term *quarter round* is derived, as its profile is exactly a quarter circle. The two fillets here are $\frac{1}{8}''$, as before, and the radius of the arc is $\frac{3}{4}''$, with its center on the inside edge of the upper fillet $\frac{7}{8}''$ from the end. The lower fillet ends directly under the center of the arc, that is, where the arc and the upper line of the fillet become tangent.

12. The fillets of the scotia are each $\frac{1}{8}''$, the upper one being $\frac{7}{16}''$ shorter than the lower one. The curve of the profile is very similar to the reverse of the echinus, but lies flatter and is more abrupt at the top. The purpose of the scotia is to present a molding that will show a deep shade, or shadow, at its top that gradually diminishes to full high light at the bottom. It gets its name from this deep shadow effect—scotia being derived from the Greek word *skotos*, meaning "darkness."

The Roman form of scotia is contoured by means of two arcs of circles, the smaller one forming the top and the larger one being drawn tangent to it and to the lower fillet. The relative sizes of these two arcs is purely a matter of individual taste. In this example, the larger has a radius equal to three-fourths the distance between the fillets, and its center is at *c* on the under line of the upper fillet. The center of the smaller arc is directly below *a*, at *o*, one-third the distance between the fillets; *cod* is a line through the centers of both arcs and their point of tangency *d*.

13. The Greek torus has two $\frac{1}{8}''$ fillets, the upper one extending to within $\frac{3}{8}''$ of the end of the lower one. The curve is very similar to an inverted ovolo but much flatter. It is not always tangent to the upper fillet, and sometimes extends slightly beyond the end of the lower fillet, becoming tangent to the latter one-half the width of the fillet from the end. The Roman torus, however, consists of a semicircle with its center midway between the two fillets, to both of which it is tangent. The ends of the fillets occur directly over and under the center of this semicircle at the points of tangency.

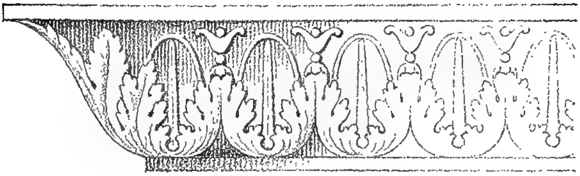
Having completed the separate moldings on the sheet in pencil, the lines should be strengthened and the whole sheet cleaned up with a soft rubber. The border and the title letters should then be inked in, as shown and as described in Art. **17,** and an alphabet of which is shown in Fig. 3. Letters may be $\frac{1}{4}''$ or $\frac{3}{8}''$ high, while the exercise and sheet numbers above, and the date, time required, and name, class letters and number below should be inserted in ink in their proper places. The sheet should be trimmed off $\frac{1}{2}''$ around the outside of the border line, making it $9'' \times 12''$. Sheet I should then be laid aside, and Sheet II proceeded with.

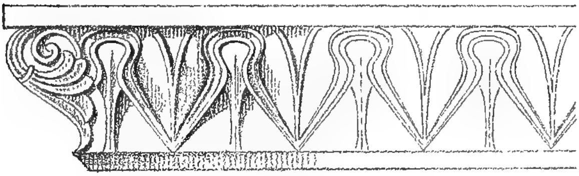
14. Exercise I, Sheet II.—Sheet II consists of four of these classic moldings having the Greek profile, and they are enriched or decorated with the style of ornament characteristic of each. After drawing the usual border lines (8 in. × 11 in.), the four moldings within them should be so proportioned as to leave a space of $1\frac{1}{2}''$ at the top. These moldings can each be made $1\frac{3}{4}''$ high by $6''$ long, and spaced $\frac{5}{8}''$ apart. This will leave a clear space of $1''$ between the ends of the moldings and the side border lines. The fillets in this case are about $\frac{3}{16}''$, and these must be drawn and the profile of the molding expressed before any attempt is made to draw the decoration.

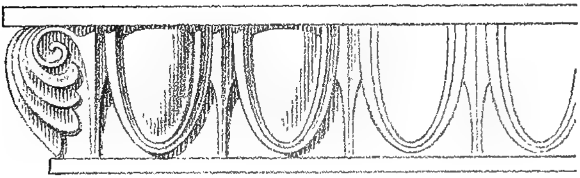
15. In making a design for the cyma recta, a vertical line should be drawn through the molding $1\frac{3}{4}''$ from the left end of the upper fillet. Other vertical lines $1''$ apart will then

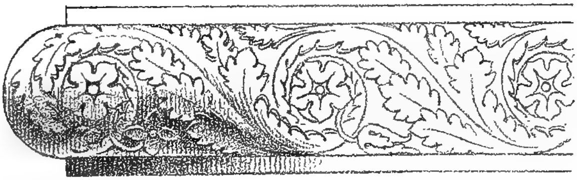
Exercise I *Title* *Sheet II*

CLASSIC MOLDINGS









Date

Time consumed in executing this sheet

Name of Student, Class Letters and Number

mark the centers of each of the sections that follow. The design should then be sketched in freehand, and worked to the required form until it is finally satisfactory. The outline of one whole section of the ornament being completed, it should be carefully traced on thin tissue paper, or tracing paper with a soft pencil. The tracing should then be turned the reverse side up and laid on the next section, so that by going over the back of it with a lead pencil the line of the decoration may be transferred. In this way the entire outline of the decorative elements of the molding may be inserted in their proper places.

When the outline is complete and before any shading is attempted, the decorative elements of the cyma reversa should be drawn in. In this case, a first vertical line may be drawn $1\frac{3}{4}''$ from the left end, and the other verticals are spaced $1\frac{1}{4}''$ apart. One of the outline ornaments should then be carefully sketched and worked up in place and traced as before, or transferred for completion in the other sections.

In the ovolo, the first vertical line is $1''$ from the left end, and the other verticals are $1\frac{1}{4}''$ apart. The torus molding contains a flowing ornament that is governed by the position of the rosettes around which it winds. The center of the first rosette is $\frac{1}{4}''$ from the left end of the fillets, and each of the other rosettes are spaced $2\frac{3}{8}''$ apart. The main veins and structural lines of the acanthus-leaf ornament should then be sketched in place for one of these designs, and transferred as before.

As even the experienced draftsman would find it difficult to execute a finished drawing of this character without numerous erasures, the beginner can to advantage draw each figure separately on other pieces of paper, according to the foregoing instruction, and when each is complete lay it aside and proceed with the next. In this way, after all four drawings are ready in outline, they may be traced on thin paper, as already suggested, and transferred separately to a clean sheet of drawing paper cut to the proper size, or ruled with the required border lines. These outlines may then be strengthened with a sharp pencil and the shading proceeded with. By this method, smudged paper and rough surfaces caused by many erasures are entirely obviated, and the result is a clean drawing full of crispness and character.

16. Observe that all shading on Sheet II is expressed in vertical lines. The purpose of shading is always to give the effect of a third dimension—that is, thickness—and but few lines are required here to express beautiful characteristics of all this relief ornament. In doing the shaded work, the pencil should be kept uniformly sharp with a long thin point. A soft pencil such as B or 2B suits the purpose admirably, but it must be kept sharp, as even a few strokes will tend to dull it and thus broaden and weaken the lines. Each shade line should be drawn by itself slowly and deliberately, to express what is required, and a little pressure should be used in order to get the result. Under no circumstances should lines be cross-hatched or placed with a zigzag motion, as this is contrary to the spirit of architectural drawing.

When the lettering is complete, it should be inked in, the figures remaining in pencil, and the sheet finished as described for Sheet I. Sheets I and II, Classic Moldings, should then be placed without folding in an envelope provided for the purpose, and mailed to the Schools for correction. A piece of stiff cardboard should be inserted in the envelope with the drawings to keep them flat, and it would be well to cover Sheet II carefully with tissue paper, neatly folded around it, in order to prevent the lines from rubbing and becoming blurred in transit. While awaiting the return of this Exercise from the Schools, the student may start to work on Exercise II.

LETTERING

17. The lettering for the titles, etc. of the drawing exercises in this Section will be similar to that used for the exercises in *Geometrical Drawing*, except that the rendering will be entirely freehand. In Fig. 3 is shown a freehand adaptation of the alphabet that was constructed geometrically for the exercises in *Geometrical Drawing*. One of the

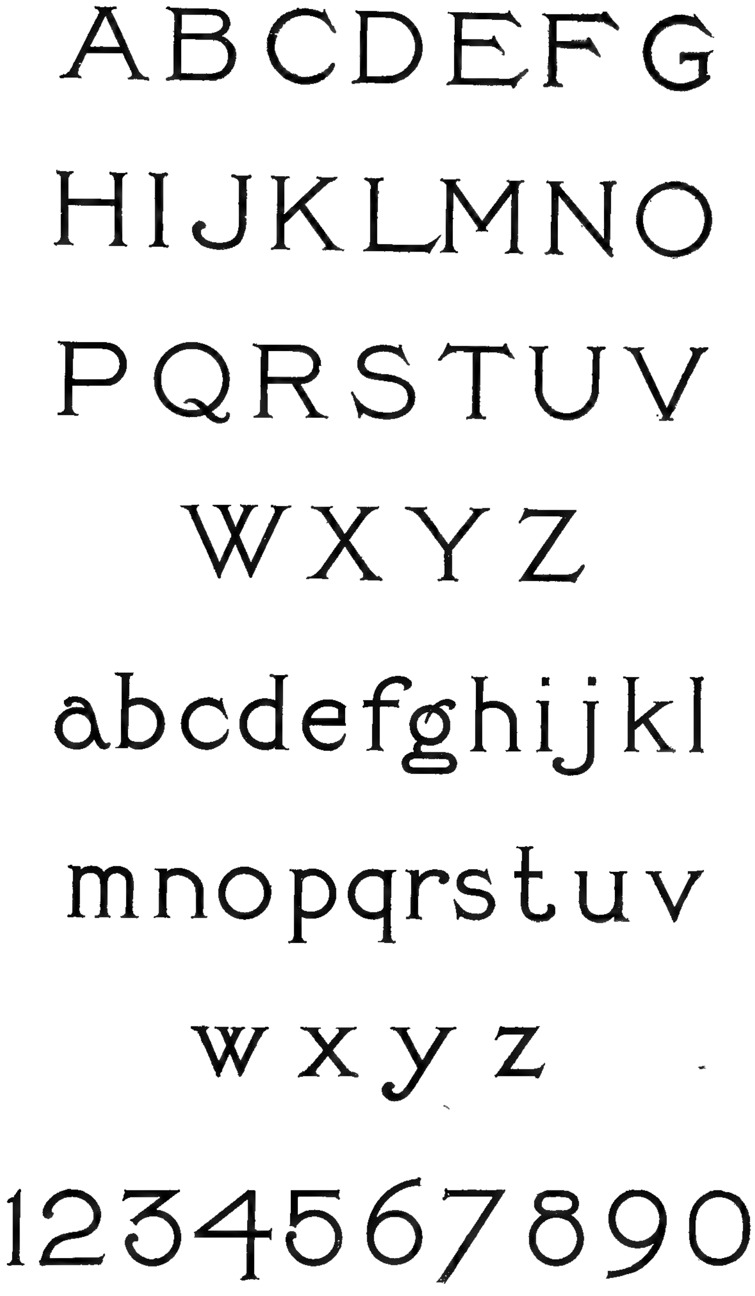

ABCDEFG
HIJKLMNO
PQRSTUV
WXYZ
abcdefghijkl
mnopqrstuv
wxyz
1234567890

Fig. 3

essential characteristics of any form of lettering is that it should be perfectly legible, so that there will be no difficulty in determining what each character represents. In order that any trifling irregularities may not impair the artistic value of the letters, it would be wise to accent the peculiarities of each letter and make it apparent that that peculiarity has been emphasized. For that reason, as in Fig. 3, the middle horizontal line of such letters as B, E, F, and H is raised considerably above the center of the letter; whereas, the loop of the R and the P is made liberal in its proportions so as to appear considerably larger or considerably smaller than one-half the letter. It matters very little which is used, so long as there has been no attempt to make the loop exactly one-half the size of the letter, as any deviation from this half size would be unpleasing unless it were great enough to show that it was intentional.

The alphabet shown in Fig. 3 should be drawn in ink on a sheet of paper 9 in. × 12 in. with a border line 8 in. × 11 in. and should be sent in with Exercise II. The upper and lower guide lines may be drawn with a **T** square, but the letters must be drawn *freehand.* The capital letters are to be $\frac{3}{4}$ inch and the small letters $\frac{1}{2}$ inch in height on this sheet, and the completion of this alphabet should familiarize the beginner with the form of the letters that are to be executed in one-half of the foregoing dimensions on the regular exercises.

EXERCISE II, TITLE: EAVES AND GUTTERS

18. In building the roof of a house the eaves are usually carried from 6″ to 24″ beyond the house line, and the method by which this projection is effected and the manner in which it is decoratively treated must be thoroughly understood by the draftsman when preparing general elevations. Exercise II, consisting of four sheets, will deal with four examples of eave construction, in two of which a gutter is formed at the edge of the roof, while in the other two, one is built up on the slope.

EAVES AND GUTTERS

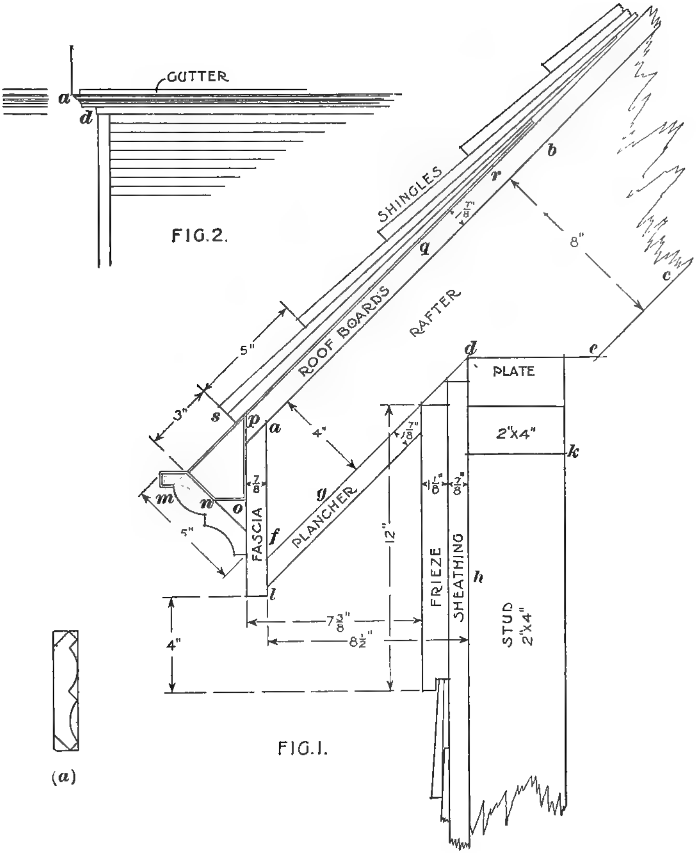


FIG. 2.

FIG. 1.

(*a*)

Date

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Name of Student, Class Letters and Number

19. Exercise II, Sheet I.—After drawing the usual 8″ × 11″ border line, locate the point *a*, Fig. 1, of Sheet I, 6″ below the top, and 3″ to the right of the left border line. From *a* draw *a b* upwards and to the right at an angle of 45°. Lay off *b c* equal to 8″ at a scale of 3″ to the foot, and through *c* draw another 45° line parallel with *a b*. From *a*, now lay off 4″ to *g*, and through *g* draw another 45° line parallel with *a b*. From *a* draw *a f* intersecting this last line at *f*, and from *f* lay off *f h* 8½″, equal to the projection of the rafter or roof beam from the frame of the house. Draw the perpendicular *h d*, and where this intersects with the line *f d* draw *de* to intersect with *e c*. Now, the surface *a b c e d f* represents the side of the rafter projecting over the plate *d k*. Draw in this plate according to the dimensions given and show also the stud supporting it from below. Show the roofing boards on the top of the rafter ⅞″ thick, and draw the fascia across the end ⅞″ thick and 7½″ deep from *a* to *l*. The sheathing covering the studs and ⅞″ in thickness is then drawn, and the frieze board or top casing is laid over this 1⅛″ thick and 12″ deep. The plancher ⅞″ in thickness should now be fitted in between the fascia and the casing as shown.

The molding *m* is then secured to the fascia about 1¾″ above the drip, or the lowest point, *l*. This molding extends up and to the left 5″ at an angle of 45°. It is cut from a piece of timber 5″ wide and 1″ thick, as shown at (*a*), and these dimensions must not be exceeded. The small triangular filler *n o* at the bottom of the gutter measures 1″ across, and serves to form a flat bottom for the gutter and to strengthen the joint between the molding and the plancher. The tin or other flashing lining to the gutter is then laid over the edge of the molding from *m* to *n*, *o*, *p*, and *q*. The section *p* to *q* is about 10″ or 12″. The thickness of this metallic gutter lining varies according to the material, and is here shown arbitrarily by drawing a single line as close as possible to the gutter outline. The piece from *m* to *p* is a metallic tie soldered to the gutter at *m* and to the tin on the roof at *p*. The shingles covering the roof are 18″ long and ½″ thick at the lower, or butt, end. The first course is laid double so as to cover the joints between the lower shingles. Draw the butt end of these, and then draw the top lines from *s* to *r*, the length *s r* being 18″. Now, draw the second course 5″ above the first, and so on until the six courses are laid.

20. Fig. 2 of this sheet represents the gutter and eave shown in Fig. 1 drawn in elevation to a scale of ¼″ to the foot. This figure presents the usual appearance of the eaves on the ¼″ scale drawings from which the house is built. In drawing Fig. 2 on the sheet, locate *a* 1″ to the right of and 2½″ below the left and upper border lines, and from this point draw a horizontal line to the right representing the top line of the molding. The vertical depth of the molding is 3½″; therefore, a line should be drawn 3½″ below and parallel with the first line representing the bottom of the molding on a scale of ¼″ to the foot. Between these two lines draw two other horizontal lines to indicate the details of the molding. The line showing the projection of the molding is drawn straight with the 45° triangle, as this scale is too small to indicate the details. The fascia is 2″, according to Fig. 1, and the frieze on the house at *d* extends about 4″ below the fascia. The projection from the frieze to the overhanging fascia is 7⅜″, as shown in Fig. 1. Leave all work in pencil and color the parts shown in section. Ink in the title, etc. as usual, laying the sheet aside until all sheets of this exercise are completed.

21. Exercise II, Sheet II.—Fig. 1 of Sheet II is constructed in practically the same manner as that in Sheet I, except that the overhang of the eaves is considerably less and the plancher is laid horizontally instead of with the slant of the rafter. To execute this figure, commence by drawing at a scale of 3″ to the foot, the end section of the plate 4″ square, 3½″ above the bottom border line, and 4½″ from the left border. Draw the stud supporting the plate 4″ wide, and then draw the lower line of the rafter at an angle of 45° from the upper right-hand corner of the plate. The bottom of the rafter is then cut off even with

EAVES AND GUTTERS

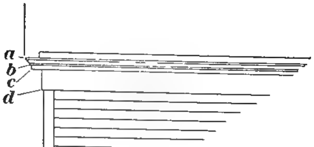

FIG. 2.

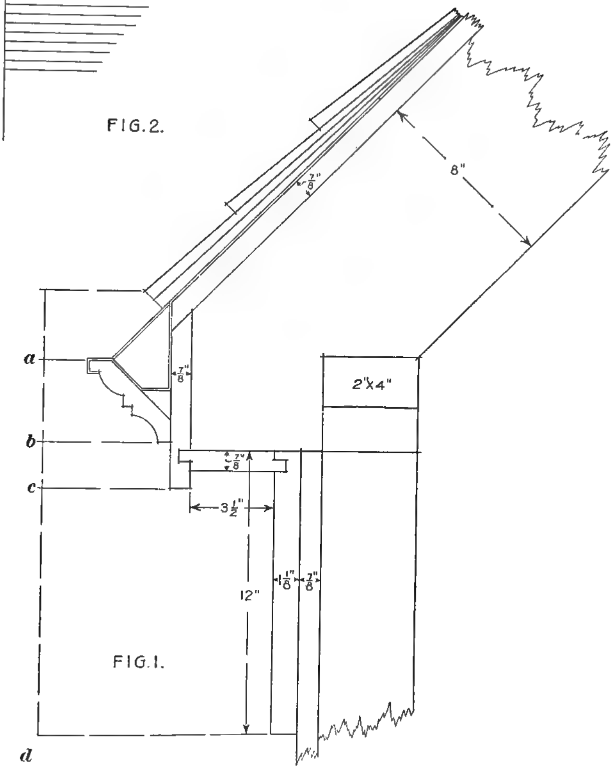

FIG. 1.

Date

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EAVES AND GUTTERS

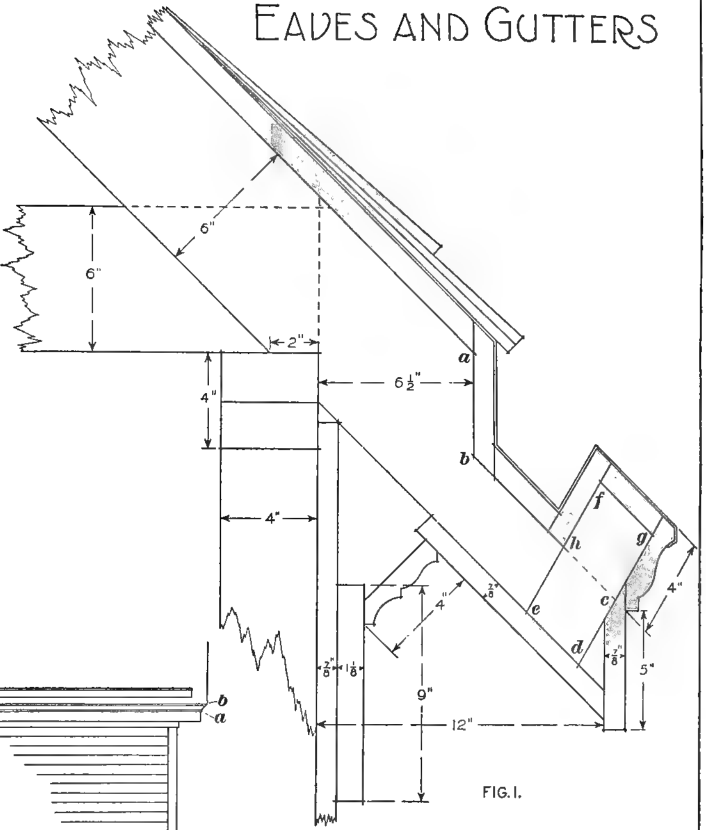


FIG. 1.

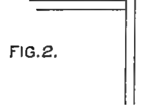


FIG. 2.

Date *Time consumed in executing this sheet* *Name of Student, Class Letters and Number*

the bottom of the plate, and the front is cut to receive the fascia 3½″ in front of the top casing, or frieze, of the house. The fascia is secured to the front of the rafters, as in the previous case, but in this instance the soffit of the cornice, or plancher board, is *dadoed* into the fascia as shown, thus making a neat and secure joint. The frieze here extends 12″ below the foot of the rafter. Render this sheet in the same manner as Sheet I.

22. In drawing Fig. 2, which is a ¼″ scale elevation of Fig. 1, the same considerations that governed the drawing of Fig. 2, Sheet I, must be observed. The lines *a*, *b*, *c*, and *d* in Fig. 2 correspond with the lines *a*, *b*, *c*, *d* in Fig. 1, and the intermediate lines between *a* and *b* in Fig. 2 represent similar lines in Fig. 1.

23. Exercise II, Sheet III.—In Fig. 1 of Sheet III is shown a third method of forming the eaves wherein the gutter is cut down into the top of the rafter instead of being formed on the foot, as in the previous cases. This construction makes a strong cornice and a very presentable detail in elevation, as is shown in the ¼″ scale elevation, Fig. 2.

To draw Fig. 1, commence by drawing the plate 4¼″ below the top and 3″ to the right of the border line. The rafter in this case is only 6″ in depth and is notched 2″ over the plate, but a ceiling beam 6″ in depth rests on the top of the plate and is spiked to the rafter so that the latter gets additional bearing value from this beam; 6½″ in front of the plate the rafter is cut in one-half its depth, as shown at *a b*, and the portion above *b c* is removed. A piece of plank *d e f g* is then nailed to the foot of the rafter, forming the gutter cut at *a b h f*. It might appear at first that a simpler method would be to cut out the section *a b h f* and form the gutter in the rafter, but this would not make a strong job. The piece *c h f g* would be liable to split off, and for this reason it is better to cut off the rafter in the beginning and apply the block *d e f g*. Carry the lower line of the rafter down until it intersects with a perpendicular drawn 12″ in front of the frame of the house. Then, draw the crown molding 4″ deep and 1″ thick, as shown, with its back at an angle of 30° with the perpendicular, and the fascia 5″ deep and $\frac{7}{8}''$ thick. The plancher is $\frac{7}{8}''$ in thickness and extends up the rafter about 10″ from the fascia. The block *d e f g* is 3″ in width, and extends to the top line of the rafter. Pieces of $\frac{7}{8}''$ plank are then fitted in at *a b* and *h f* to form the sides of the gutter.

The frieze on the main wall is 9″ in depth and extends 3″ below the bottom of the fascia, and the space between the plancher and the frieze is filled with a piece of molding 4″ in width, as shown. From the under side of the fascia to a point 12″ up on the roof, a sheet-metal flashing is carried, forming the lining of the gutter where it dips into the depression *a b h f*.

24. Fig. 2 is drawn in precisely the same manner as Fig. 2 in the previous sheets, the only difference being that the line of the crown molding from *a* to *b* is inclined at an angle of 30° with the perpendicular instead of 45°, as in the previous examples. Render this sheet in the same manner as previous ones.

25. **Exercise II, Sheet IV.**—A method of eave construction where the gutter is built on the rafter instead of being cut into it, as in the previous case, is shown in Fig. 1 of Sheet IV.

To draw Fig. 1, locate the plate 4″ above and 2″ to the right of the bottom and left border lines. Draw the rafter 6″ deep at an angle of 45°, notching it over the plate so as to leave a projecting eave rafter 4″ deep. Cut the end of the rafter vertically 11″ in front of the stud. Then, after drawing the $\frac{7}{8}''$ sheathing on the outside of the stud, the rough frame is complete, and the details can be taken up.

The $\frac{7}{8}''$ fascia board is laid on the end of the rafters, and its top is beveled with the slope of the roof. The roofing boards are carried $2\frac{1}{4}''$ beyond the fascia; then the crown molding is so placed as to show 3″ of fascia below it. The plancher and frieze are constructed exactly as in the previous example, but of different proportions.

EAVES AND GUTTERS

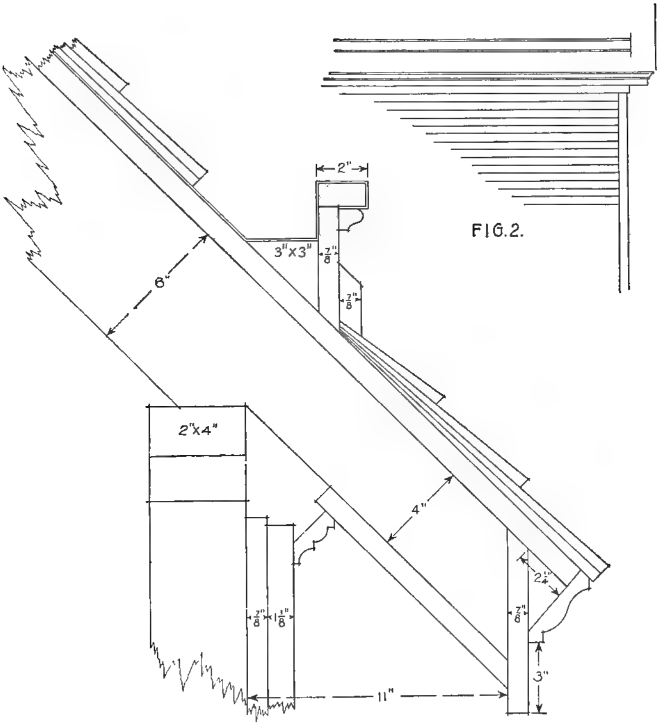


FIG. 2.

FIG. 1.

Date *Time consumed in executing this sheet* *Name of Student, Class Letters and Number*

Three courses of shingles, exposed 5″ to the weather, are laid on the roof, the first course being projected sufficiently to allow the drip from the under shingle to fall clear of the crown molding. The third course is cut off so as to permit the 3″ × 3″ bedplate of the gutter to be secured *outside* the line of the building wall. The under side of the bedplate is beveled to suit the slant of the roof, and the face board extends 1½″ above. The cap placed on the face board is 2″ wide, and is supported in the outside angle by a 1″ × 1″ ogee molding, while the base of this board is formed of a piece of ⅞″ material that is beveled on top at an angle of 45° and on the bottom to fit the slope of the shingles. The flashing is carried from the cap of the face board well up under the shingles, as shown, and the first of the upper courses of shingles is laid about even with top of gutter.

As with the previous examples, the elevation at ¼″ scale, as shown in Fig. 2, is drawn according to the measurements obtained from the projection of the details in Fig. 1.

This sheet is then rendered like the previous ones; and the entire four sheets of this Exercise, together with the sheet of lettering asked for in Art. **17,** should be stiffened with cardboard and mailed flat to the Schools for correction.

STRUCTURAL DETAILS

26. While the architectural draftsman should possess a complete knowledge of construction obtained largely by actual practice, yet a great deal can be learned through a study of the principles underlying the work of construction.

Three general materials, namely, stone, iron, and wood, enter more largely than any others in the construction of the modern building. Iron, however, in the majority of cases is concealed under wood or stone details, and its specific design comes in the province of another profession —that of the architectural engineer. Stone and wood, therefore, are practically the only materials that the average draftsman has under consideration throughout his entire career, and it is in these materials that the principal features of his designs are carried out. Brick, tile, and terra cotta are really a sort of artificial stone, and are therefore considered under this general head.

27. Wooden buildings are of two classes of construction. Those that are carefully framed together with all the joints fitted like the details of a piece of furniture, called **braced-frame construction,** form one class, and include such structures as large mills, warehouses, coal pockets, and other buildings that require great strength. The framework of the building itself is made to withstand all strain regardless of the covering or finishing material. The other class, called **balloon-frame construction,** has its framework simply nailed together, with seldom any fitting of joints. The framework in this case is a very flimsy affair, but when covered with sheathing boards laid diagonally, each board acts as a brace and helps to secure each portion of the frame to which it is nailed; thus, when entirely complete, the building is homogeneous and stiff and capable of standing all the strain that it is likely to receive. This system of framing is used for residences, stores, and other buildings where great strength is not required.

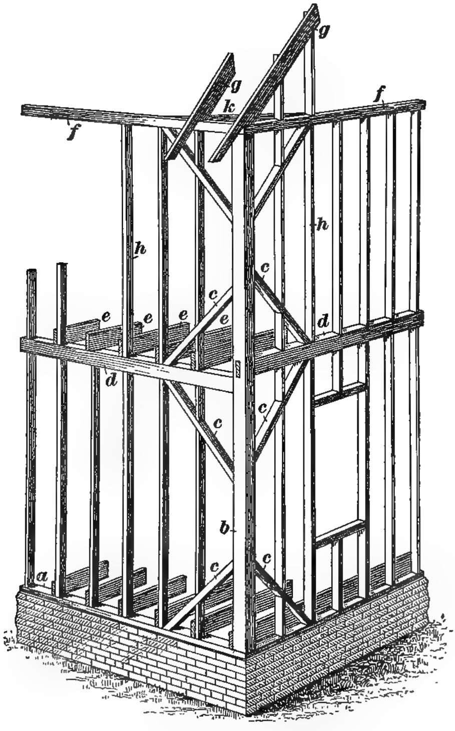


FIG. 4

28. In Fig. 4 is shown the corner of a building that will serve to illustrate the system of braced-frame construction. On the top of the brick foundation wall, a wooden sill *a* is set as shown, and at the corner of this wall a post *b* about 8″ square is erected, its lower end being mortised into the sill. The braces *c* are each similarly mortised into the post and the sill, and also into the girth at *d*. The girths are mortised into the post, and are held in place by means of a wooden pin. The second-story beams *e* are supported by the girths, while the first-story beams rest on the sill. Between the sill and the girths, and between the girths and the plate *f*, the studs *h* are framed 16″ apart. These studs are mortised into the girth and the sill, and the second-story studs, into the girth and the plate. The rafters *g* support the roof cover and these rest on the plate as shown. A horizontal brace *k* framed into the upper corner of the building stiffens the construction at this point so that the whole structure is, in itself, strong and substantial. All timbers are large and carefully framed together.

29. The balloon-frame type of construction is shown in Fig. 5. The sill *a* is set back of the brick foundation wall about 1 inch, so that the sheathing *g* will come flush with the brickwork. The corner posts *b* may be mortised into the sill in the same manner as in braced-frame structures, but more often they are secured in place by simply boring 1-inch holes into the sill and the end of the post, and then inserting a dowell, or pin. Wherever possible, the studs *c* are in one piece, extending from the sill to the roof plate *d*, but if the proper length cannot be obtained, they are spliced. The studs are simply nailed into position, and the girths *e* that support the second-story beams *f* are nailed on the face of these studs. The sheathing *g* is securely nailed to each side of the structure in a diagonal position, and serves to brace it thoroughly. In putting on the sheathing no attempt is made to fit it to the window openings, but these openings are sawed out, as shown at *h*, after the sheathing is placed. Temporary braces, as shown at *k*, are usually employed to

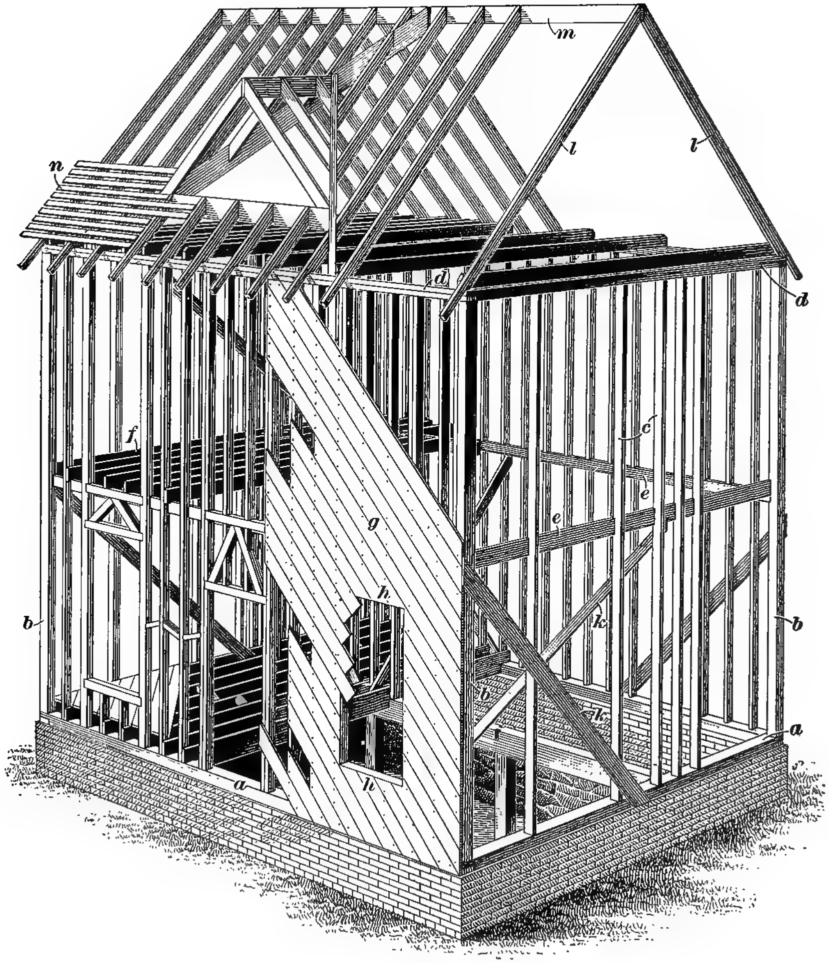
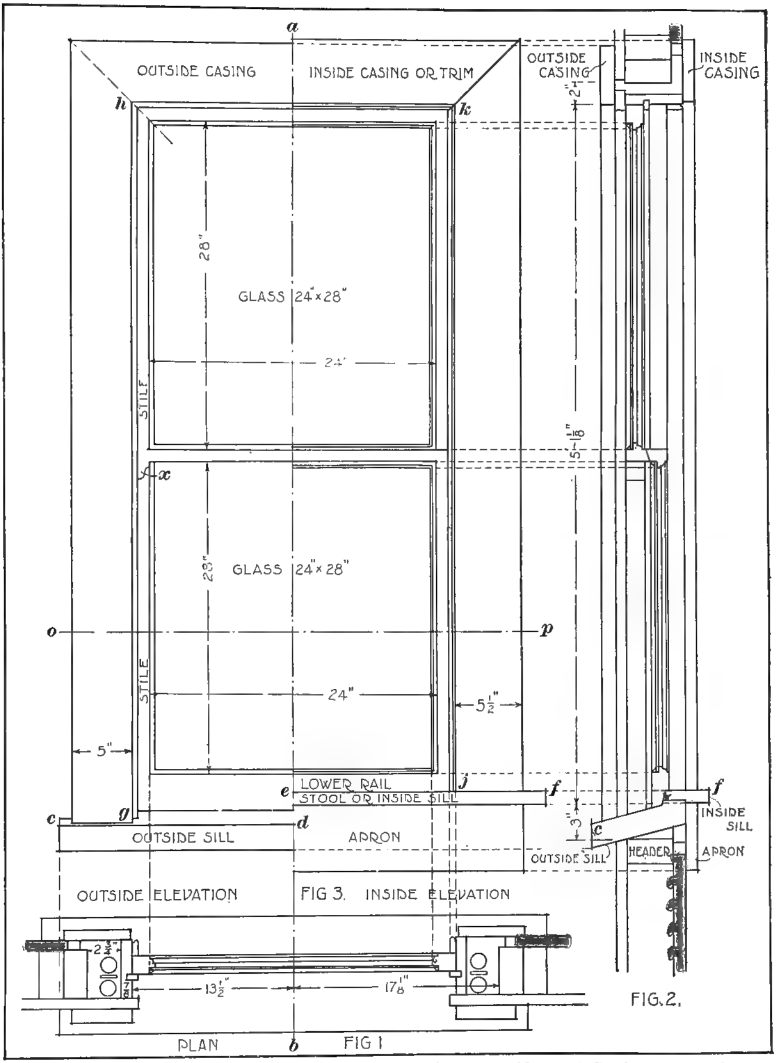


FIG. 5

Exercise III *Title* *Sheet 1*



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hold up the structure until the sheathing is placed and the building is rendered secure.

The lower ends of the roof joists, or rafters, *l* rest on the plate *d*, while at the head they rest on the ridge board *m*. The ceiling beams of the second story are nailed to the rafters wherever practical, and thus tie the two ends of the rafters together and overcome any tendency they may have to spread out and slide off. In buildings where the ceiling beams are so placed as not to give convenient nailing space for the rafters, a tie is generally carried across the building and nailed to each pair of rafters so as to prevent them from separating, as in Exercise II, Sheet III.

Shingle laths consisting of small strips of wood, as shown at *n*, are sometimes laid over the rafters at intervals of from 4 to 6 inches, according to the way the shingles are to be spaced. In some cases, roofs are covered with wide boards laid close together, but this is not as good as using shingle laths, as it prevents the proper ventilation of the under side of the shingles with which the roof is finally covered.

EXERCISE III, TITLE: WINDOW DETAILS

30. Exercise III consists of two sheets upon which the student will work simultaneously, going from one to the other alternately. Sheet I shows the details of the elevations (seen from inside and outside) and sections (through top, sides, center and bottom of sash and framing details) of a window in a frame house. The conventional representation of a window in the elevation of a house at $\frac{1}{4}''$ scale is shown on Sheet II with illustrations of the methods of spacing the studs in the side walls in order to provide sufficient opening for the window frame, and also details of the various sectional parts. The sizes of the material used in window construction will vary slightly in different examples of window framing, and therefore are exact for this particular case only. The thickness of any one of these pieces may be varied for the sake of appearance, construction, or economy. The outside sheathing boards of a building are usually $\frac{7}{8}$ inch thick, and consequently the blind stop of the window frame is made the same thickness, as may be seen by referring to Sheet II. The outside casing, however, is made thicker, not only for appearance, but also for structural reasons. The clapboards, siding, or shingles with which the sheathing boards are covered finish against the outside casing, and the thickness of this casing must therefore be sufficient to cover the ends of these clapboards. As the inside casing forms a finish between the plaster and window frame, it need be only $\frac{7}{8}$ inch thick, while the sashes are $1\frac{1}{2}$ inches thick in order that they may be strongly framed together and to protect the glass. When the studding in the walls is more than 4 inches deep, the sash may be thicker than $1\frac{1}{2}$ inches, otherwise it must be this thickness.

These few instances are given simply to illustrate that variations in dimensions may be made for specific reasons, and while the draftsman may change sizes to suit his convenience in general practice, the fact that strength should be the first consideration should always be borne in mind. Good draftsmanship does not consist merely in the ability to lay out accurate drawings; it involves an intimate knowledge of the construction that lies beyond exterior appearance. Every fixed measurement is dependent on some detail or rule that determines that measurement, and no fixed dimension should be settled arbitrarily.

31. Building Materials.—Rough lumber comes from the mill in thicknesses of 1 inch, $1\frac{1}{4}$ inches, $1\frac{1}{2}$ inches, and 2 inches, and the planing and finishing reduces the size from $\frac{1}{8}$ to $\frac{1}{4}$ inch. The dimensions given on building plans usually call for lumber $\frac{3}{4}$ inch, $\frac{7}{8}$ inch, 1 inch, $1\frac{1}{8}$ inches, $1\frac{1}{4}$ inches, $1\frac{1}{2}$ inches, and $1\frac{3}{4}$ inches in thickness, which are obtained from the rough sizes planed down.

Window glass comes packed in boxes that hold from one-quarter to twelve dozen, depending on the size of the panes. Cutting standard sizes of glass into odd sizes creates waste, and it is sometimes desirable that sashes should be so proportioned as to use the window glass economically.

Therefore, the dimensions of the sashes are more or less dependent on the sizes and number of the panes.

Studs, joists, and other timbers used in building construction to support lath for plaster work are usually spaced 16 inches apart, as the laths are 48 inches long and can thus be nailed to three studs, bringing the joints on the third stud. A variation of this space may be necessary in some places, but it is always best, whenever practicable, to have them work out in even multiples of 48 inches, as otherwise there would be waste of material.

Common bricks are 4 inches in width by $8\frac{1}{4}$ inches in length by 2 inches in thickness, and the joints between them are usually about $\frac{1}{4}$ or $\frac{3}{8}$ inch. Thus, a brick wall is $12\frac{1}{2}$, $16\frac{3}{4}$, or 21 inches in thickness, according to the number of bricks used. Owing to the convenience of expression, however, these walls are usually called 12-, 16-, and 20-inch walls, and on small scale drawings the walls are usually indicated at this thickness; but in making large detail drawings the actual dimensions are always in excess of these even figures. Table I gives the sizes of a number of brands of pressed brick and firebrick.

TABLE I

BRANDS AND SIZES OF BRICK

Name	Thickness Inches	Width Inches	Length Inches
Common brick	2 to $2\frac{1}{4}$	4	$8\frac{1}{4}$
Philadelphia, pressed	$2\frac{1}{4}$	4	$8\frac{3}{16}$
Peerless Brick Company	$2\frac{3}{8}$	$4\frac{1}{2}$	$8\frac{3}{8}$
Baltimore and Trenton	$2\frac{3}{8}$	$4\frac{1}{8}$	$8\frac{1}{4}$
Croton	$2\frac{1}{4}$	4	$8\frac{1}{2}$
Colabaugh	$2\frac{3}{8}$	$3\frac{5}{8}$	$8\frac{1}{4}$
Maine, common	$2\frac{3}{8}$	$3\frac{3}{8}$	$7\frac{1}{2}$
North River, common	$2\frac{1}{4}$	$3\frac{1}{2}$	8
Milwaukee	$2\frac{3}{8}$	$4\frac{1}{8}$	$8\frac{1}{2}$
Stourbridge firebrick	$2\frac{3}{8}$	$4\frac{5}{8}$	$9\frac{1}{8}$

32. Exercise III, Sheet I.—Sheet I is to be drawn to a scale of $1\frac{1}{2}''$ to the foot. Fig. 3 shows the exterior and interior half elevations of a window containing two panes of glass 24 in. × 28 in., while in Fig. 2 is shown a vertical section through the window on the line *a b* of Fig. 3, whereon the details of the window head, meeting rails, and bottom rails and sill construction are given. Fig. 1 shows the section through the weight boxes and casing on the line *op* of Fig. 3.

Fig. 1 of Sheet II shows enlarged details of the window head, sill, and meeting rails, which are to be drawn to the scale of 3″ to the foot. In Figs. 2 and 3 are given details of the weight box at the same scale, and Fig. 4 shows the conventional form of window rendering as it appears in the quarter-scale drawing of an elevation. In order that the student may become familiar with the details of these parts before they are drawn to the smaller scale required hereafter, this exercise should be commenced by drawing the first two figures of Sheet II on a practice sheet of paper.

33. Exercise III, Sheet II.—Commence Sheet II by drawing Fig. 1 (*a*) to a scale of 3″ to the foot. The two pieces of 2″ × 4″ studs that form the header at the top of the window are located 2″ below the upper border and $1\frac{1}{4}''$ to the right of the side border line. On the outside of these headers, the $\frac{7}{8}''$ sheathing should be shown reaching to the lower edge of the header, while on the inside the plaster $\frac{7}{8}''$ in thickness should also be indicated. Now, between the sheathing and the plaster line, the yoke, or window head, $\frac{7}{8}''$ thick, is drawn 1″ below the headers, and the blind stop, about 2″ in width and the same thickness as the sheathing, is nailed to the end of the yoke and extends $\frac{1}{2}''$ below it. The upper sash rail $1\frac{1}{2}''$ in thickness is now drawn in place 2″ in depth, with the glass bedded into the rabbet, as shown in Fig. 6 of the text. The parting strip, or bead, holding the upper sash in place is $\frac{1}{2}''$ thick and 1″ wide, and is let into the yoke about $\frac{1}{2}''$. The stop-bead is placed $1\frac{1}{2}''$ from the parting strip, so as to

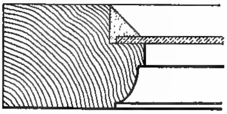

FIG. 6

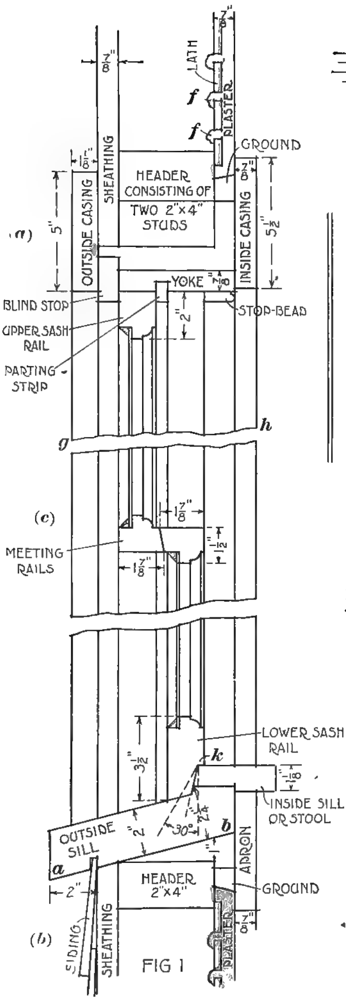

FIG 1

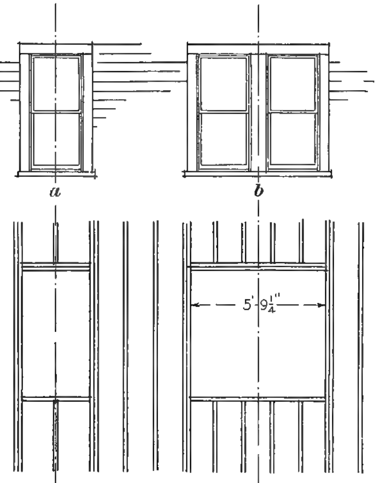

FIG. 4

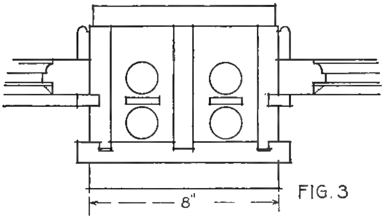

FIG. 3

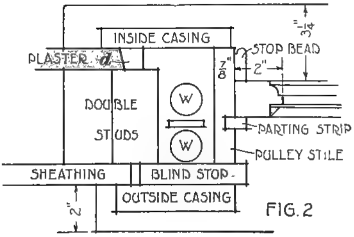

FIG. 2

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allow the lower sash to slide up, and this stop-bead is usually about wide enough to reach to the inner line of the plastering but varies according to circumstances, as will be shown hereafter. The laths are about $\frac{1}{4}''$ thick and $1\frac{1}{4}''$ wide, and are spaced about $\frac{3}{8}''$ apart to permit the plaster to be squeezed through them and form a key on the inside. The first lath laps over one-half the width of the stud, and the second is spaced $\frac{3}{8}''$ from the first. The ground is $\frac{7}{8}''$ thick, corresponding with the thickness of the plaster, and is 1″ wide on the inside. The side next to the stud is beveled off to $\frac{7}{8}''$, however, so as to form an inverted wedge, or key shape, that will hold the plaster in place. When the plaster is applied, portions of it are squeezed between the laths and curl over on the inside to form the key already mentioned, as shown at *f*. The outside casing $1\frac{1}{8}''$ thick and 5″ wide may now be drawn in place, its lower edge being even with the under side of the yoke. This outer casing is nailed through the sheathing to the header and through the blind stop to the yoke, thereby holding the outside of the window head securely in place. The inside casing is nailed through the plaster ground—into the header on one side and directly to the yoke on the other. This casing is $\frac{7}{8}''$ thick and $5\frac{1}{2}''$ wide, and its under edge is raised about $\frac{1}{8}''$ above the lower edge of the yoke. The lines of the various details of the drawing should now be carried down toward the bottom of the sheet in order to mark their positions in the section through the sill and lower sash rail, but a short distance below the upper sash rail a broken line should extend across the details, as shown at *g h*, to indicate that vertical scaling is not to be made beyond this point.

34. In drawing the section through the sill of the window, as shown in Fig. 1 (*b*), the header of the sill is directly below the two headers at the top of the window and 1″ above the lower border line. The sheathing boards are shown on the outside of it and the plaster on the inside, as before. The outside sill is 2″ in thickness on the outer face and extends 2″ beyond the sheathing. It is inclined, or pitched.

1″ in 4″, so that while it rests on the header at the outer edge it is 1″ above the header on the inside edge. To get this pitch correctly, it is necessary only to locate a point 1″ above the inner edge of the header, and then draw the line *a b* through the point so located and the outer corner of the header. The thickness of the sill may then be laid off as shown, and the upper side drawn parallel with the lower side.

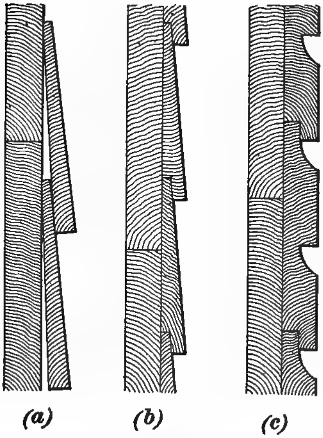


FIG. 7

Clapboards, siding, or shingles are usually laid over the outside sheathing, and as siding or clapboards are cheaper than shingles, they are therefore more frequently used. Clapboards are used almost entirely in the New England States where they had their origin. Siding is similar to clapboards in form and is used throughout the country. Ordinary, or beveled, siding comes in lengths from 10′ to 16′. It is 6″ wide and $\frac{5}{8}$″ thick at the bottom and $\frac{1}{4}$″ thick at the top, and is laid with a lap of 1″ to $1\frac{1}{2}$″, as shown in Fig. 7 (*a*) of the text, making an excellent weatherproof covering. An improvement on the ordinary siding, known as Boston siding, is shown at (*b*). It is rabbeted $\frac{5}{8}$″ on the lower edge to fit over the upper edge of the piece below, and thus requires nailing only on one edge, as shown. Besides these there are various forms of molded siding called *Drop*, or *Novelty*, *siding*, as shown at (*c*). Sometimes, in very cheap work, the siding is laid directly over the studs without the intervening sheathing, but this makes a poor job and a cold building. In fact, heavy felt or tarred paper should be laid over the sheathing for the best work, as it adds greatly to the warmth and comfort of the house. Draw the beveled siding in Fig. 1 of this sheet, as indicated.

The stool, or inside sill, as it is sometimes called, is 1⅛″ thick and is rabbeted ¼″ to fit over the top of the outside sill. The apron is ⅞″ thick, and is secured to the sill and also to the plaster ground. The lower rail of the window is 3½″ in depth outside, and is beveled on its inner edge so as to form an inner joint when closed against the stool. The amount of this bevel is about 15°, and it may be drawn with sufficient accuracy by first laying off 30° with the triangle, as shown by the dotted lines, and then bisecting this angle to get 15°. The small shoulder formed at the end of the bevel at *k* is about ¼″. Now, draw the lines of the outer casing, blind stop, parting strip, and inner casing down to the sill details as shown. The siding over the sheathing is 6″ wide, ⅝″ thick on the lower edge, and about ⅜″ on the upper edge. In general practice, it is laid with an overlap of from 1″ to 2″ and is usually described as being laid 5″, 4½″, or 4″ "to the weather," which means that the boards are nailed to the side of the house with a lap sufficient to expose this amount of surface. In this example, they are laid 4″ to the weather, and to gain uniformity, the top board is planed down so that its width below the sill will be the same as the others.

35. In Fig. 1 (*c*) are simply shown the meeting rails of the upper and lower sashes midway between the yoke and the stool. These rails are made 1⅞″ in width in order that they may fit across the parting strip and make a tight joint. Their meeting edges are beveled so that when they come together a tight joint will be formed, and the rails are also prevented from catching when their edges pass in closing. After drawing the meeting rails, project the lines of the casing, etc., as before, and complete the figure with all the dimensions as shown.

36. In Fig. 2, Sheet II, is shown a section through one side of the window on the line *op* of Fig. 3, Sheet I. Draw the double studs in Fig. 2, 1″ above the lower border line and 3″ to the left of the side border line. Draw the sheathing outside and the plaster inside, as before, and then indicate the pulley stile $\frac{7}{8}''$ thick extending from the inside plaster line to the sheathing and $2\frac{3}{4}''$ away from the double studs. The inside casing then secures the pulley stile in position, as it extends over the space between the stile and the plaster ground *d*. The blind stop extends $\frac{1}{2}''$ beyond the pulley stile, as it did with the yoke in Fig. 1, but here it extends back and is also nailed to the stud, thereby securing the outer edge of the pulley stile in place. The outside casing is secured over the blind stop and the sheathing, as was done in Fig. 1. The sill projects beyond the casing and returns across the end of it, as shown, the amount that the sill extends being shown in Fig. 1 as $2''$ from the sheathing line. The parting strip is $\frac{1}{2}''$ thick and $1\frac{1}{2}''$ from the blind stop, and the inner sash is $1\frac{1}{2}''$ thick and extends from the parting strip to the stop-bead, which is $\frac{1}{2}''$ in thickness and extends from the sash to the inside plaster line. The width of the stile of the sash is $2''$. On the inside, the stool projects $3\frac{1}{4}''$ beyond the sash line and returns around the inside casing to the plaster, as shown. The sash weights *w* are $1\frac{3}{8}''$ in diameter, and are located directly in line with their respective sashes.

The woodwork on this plate that is shown in section should be colored with a light wash of burnt sienna, as shown in Figs. 1, 2, and 3 of this exercise. Having completed Figs. 1 and 2 of this sheet, Sheet I should be taken up.

37. Exercise III, Sheet I.—Fig. 1 of Sheet I will now be considered. Locate the center line *a b* $3''$ to the right of the border line and draw the double studs of the horizontal section $\frac{5}{8}''$ above the lower border. Draw in these double studs as shown and frame the various details around them in precisely the same manner as was directed in the case of Fig. 2, Sheet II, but on a scale of $1\frac{1}{2}''$ to the foot. When this sectional plan is entirely completed, the sectional parts should be colored with burnt sienna so that the details may be readily distinguished.

Now proceed with the vertical section, Fig. 2, first drawing the double-stud header at the top of the window, and the single-stud header under the sill 1″ to the left of the border line, the former $\frac{1}{4}$″ below the top, and the latter 5′ 6$\frac{1}{8}$″ (according to scale) below it. Draw in the details of the window head and sill construction in precisely the same manner as these details were drawn in Fig. 1 (*a* and *b*) of Sheet II, but at the reduced scale of 1$\frac{1}{2}$″ to the foot. Midway between the top and bottom sash rails, draw the meeting rails as before. This should allow for two panes of glass 28″ in height, thus permitting the use of a standard size of glass —24″ × 28″. Complete the vertical section as shown in Fig. 2, Sheet I, and color all the sections as before. Then, proceed with the exterior and interior half elevations of Fig. 3.

Draw the top of the outside sill *c d*, Fig. 3, by projecting a line across from *c*, Fig. 2; and the top line of the inside sill *e f* by projecting a line across from *f*, Fig. 2. Draw the line of the outside casing *g h* over the line of the casing in the horizontal section, Fig. 1, and the line of the inside casing *j k* over the line of the inside casing in the horizontal section. The under side of the top casing, both outside and inside, is now to be drawn by projection from the under side of the top casings in the vertical section, Fig. 2.

The outline of the outside and inside openings now shows on the drawing, Fig. 3, as the rectangle *g h k j*. Through *h* and *k* draw light lines with the 45° triangle, as shown, and then complete the framing of the casings either by laying off their widths at 5″ and 5$\frac{1}{2}$″, respectively, or by projecting these widths from the horizontal and vertical sections. The line of the blind stop on the outside and the stop-bead on the inside will appear $\frac{1}{2}$″ within the line of the casings, and the sash lines will appear 1$\frac{1}{2}$″ within this, except at the bottom, where the stop and bead rest on the sills and the sash rail is wider. All these details, including the meeting rails, should be located by projection from the vertical and horizontal sections, so that each detail may be found in its exact place. Take particular notice that on the inside elevation the meeting rail of the upper sash lies under or beyond that of the lower sash, while on the outside elevation the upper sash is outside or in front of the lower sash.

The stile of the upper sash is carried at *x* about 1½″ below the meeting rail and finishes with the ogee. This makes a more attractive and stronger sash than the one cut off flush with the bottom of the rail, and is therefore preferable when the slight difference in cost is not a consideration.

Having finished the sheet, fill in the dimensions as shown and letter the parts carefully, studying the name and purpose of each so that you can recognize it whenever it is referred to hereafter. The title of the exercise, its number, and the sheet number should be lettered in ink at the top, and the date, time consumed, and name, class letters and number, at the bottom, as usual. The drawing itself should be left in pencil with the sections colored as directed. If any of the pencil lines appear too weak, go over them again after the sheet is finished, or you may ink the lines if you prefer. However, it is well that you should learn to make neat, clean, accurate pencil drawings, as in general architectural practice there is little inking done except when drawings are traced, as will be explained later.

38. Exercise III, Sheet II.—Now proceed to complete Sheet II. Fig. 4 is to be a ¼″ = 1′ scale drawing of the window given in Fig. 3, Sheet I, with a single opening at *a* and a mullion window at *b*. A mullion window consists of a group of two or more sashes that are separated by a vertical bar, called a **mullion,** as shown. Below, at *c* and *d*, is shown the method of framing the side walls of a house in order to provide for these openings in the studding. These studs, which are 2″ in thickness, are spaced 16″ apart on centers, and at the side of the opening two studs are spiked together to give increased strength. A single stud is fitted in horizontally between the double studs to form the sill, and above this sill two studs are fitted in to form a pair of headers. To draw the window *a* of Fig. 4, first make the opening inside of the casing 2′ 3″ × 5′ 2⅝″. The casing is then shown 5″ wide. The sill is drawn 2″ thick below the casing, and the blind stop is drawn inside the casing, and lastly the sash rails and stiles. The center lines of *b* and *a* are located 1⅝″ and 3¾″ to the left of the border line, respectively.

Now, draw a vertical center line through the sashes in *a*, and continue this center line down so as to lay off at *c* an opening in the studding to receive a window frame similar to the ones just drawn. It will be observed from Fig. 1, Sheet I, that the double studs are located 17⅛″, or 1′ 5⅛″, each side of the center of the opening. In rough framing, however, such minute measurements cannot be laid off, so the studs are spaced 1′ 5½″ each side of the center in the rough framing, and the difference is taken up in the weight box when the window is put in place. The height of the opening between the headers is laid out at 5′ 6⅛″, as shown in Fig. 2, Sheet I, and the studs each side are spaced 16″ from center to center. The spacing of the studs between the double studs at the sides of the opening is divided equally, which makes them less than 16″ from center to center. In measuring the width of the opening for the mullion window, the extra width of the mullion must be taken into consideration; therefore, Fig. 3 of Sheet II should be drawn before *b* and *d* of Fig. 4 are outlined, in order to better understand the construction.

Draw Fig. 3 directly over Fig. 2, placing the outside casing about 3¼″ above the border line. Place the two pulley stiles and sash details precisely as in Fig. 2, but make the casings wider as shown. Draw the window *b* of Fig. 4 as two complete sashes, like *a*, but with a mullion 8″ wide between them, instead of the 5″ casing as before. The opening at *d* in Fig. 4 will then accommodate the mullion window.

This will complete both sheets of Exercise III, and all parts should be carefully lettered in pencil as shown, the title lettered in ink being placed at the top with the other lettering each side of it, and also the name, date, etc. at the bottom.

These sheets will then be stiffened and mailed flat, as before, to the Schools for correction.

39. Other Forms of Window Construction.—The window shown and detailed in Exercise III is merely a

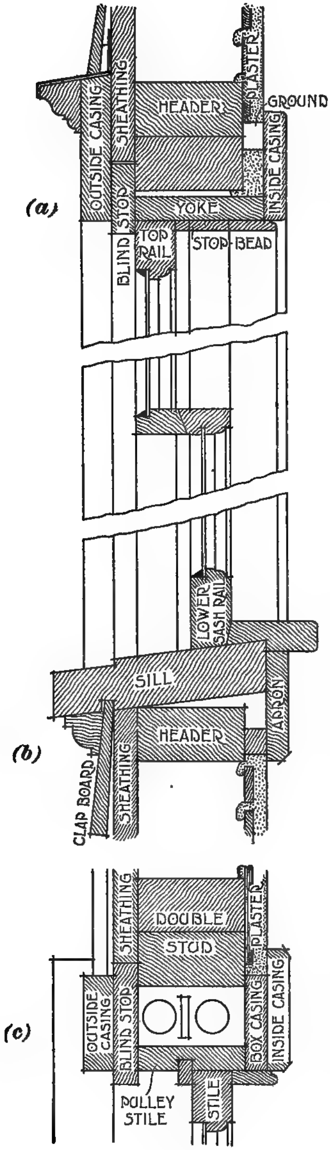


Fig. 8

typical example of the simplest forms of window construction used in balloon-frame buildings. The window may be made more serviceable under certain conditions, although at an increased cost, by modifying various details, as illustrated in Fig. 8, which shows a section through the window head at (*a*), through the sill at (*b*), and through the weight box at (*c*). Here, the outside casing is ornamented by a molding that forms a cornice, and sheet metal is laid over the top of this molding and carried up under the clapboards in order to make the window head weather-tight. Sheet metal used for this purpose is usually termed **flashing.** Note the great difference in the space between the yoke and the headers in Fig. 8, and that in the drawing exercise; also, observe in Fig. 8 that the blind stop is secured to both the yoke and the header, thus making a firmer job. The stop-bead is increased in width at the top of the window and carried through to the parting strip, giving a more satisfactory finish inside. The plaster here is carried entirely down to the yoke, thus acting as a wind stop and completely closing the joint. The ground is located so that the inside casing can be nailed through it in every case, as this prevents the plaster from cracking when nails are being driven to fasten the trim in place. The sill is similar in construction to that shown in Exercise III, but has a rabbet cut where it intersects with the blind stop. This forms a lower blind stop across the sill, so that the blinds hung on the outside casing shut against it. The molding placed under the sill, as shown in Fig. 9, where the effect of the cornice and molding are apparent, gives it a somewhat more ornamental appearance.

The difference in the sections through the weight box lies only in the fact that the box is enclosed by a rough casing on the inside corresponding with the blind stop on the outside, and this rough casing is covered by the inside casing, while the stop-bead is wide enough to extend over on this casing.

The system of construction used in Fig. 8 permits a hardwood finish throughout the interior. The sill and yoke, which are of soft wood painted so as to be weather-proof, are entirely covered inside. The stop-bead extends all the way across the soffit of the window on the interior, and beyond the joint between the yoke and the inside casing, while at the side of the window, as shown in Fig. 8 (*c*), the stop-bead extends beyond the rough casing on to the finished casing, which could be of hardwood.

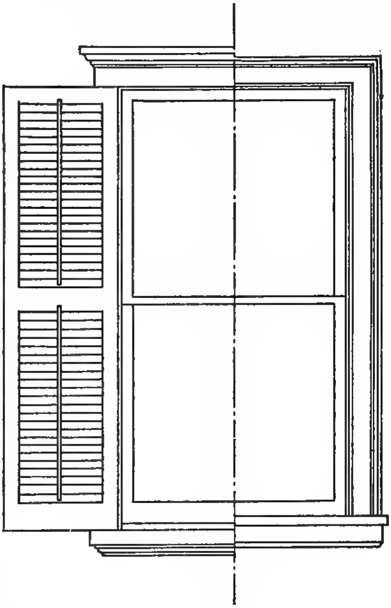


FIG. 9

40. A cheaper form of window, differing principally in the treatment of the window head, is shown in Fig. 10. Here,

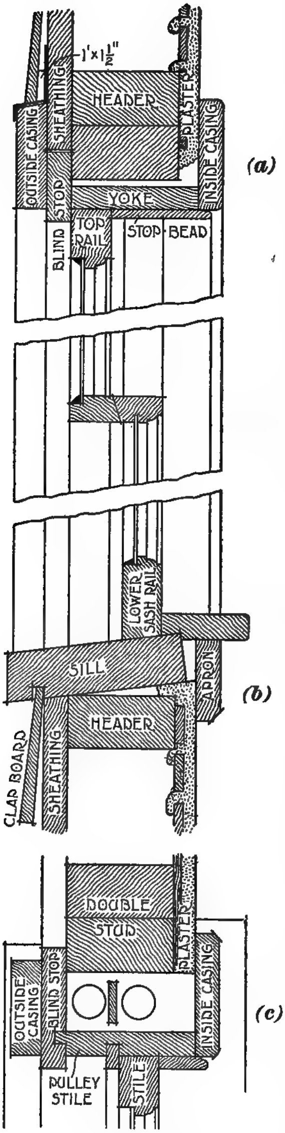


FIG. 10

the clapboards are brought down to the top of the outside casing as before, but the crown member is left off, and the flashing is brought down and turned over the top of the outside casing. The sill is the same thickness throughout, but the lower edge of the window sash is not beveled off to make a tight joint against the stool. No plaster grounds are shown under the inside casing, and the plaster is carried out to the opening of the weight box. This method is used only for the cheapest sort of work, and even then should be avoided where possible.

41. Windows in Brick Walls.—The construction of a window for a brick wall is somewhat different, as shown in Fig. 11, where it will be observed in the section through the head of the window at (*a*), that the outside casing is replaced by a stone lintel, while above the opening of the window and inside of the brick casing a wooden lintel is placed, over which a flat arch of brickwork is turned to support the wall. Vertical strips of wood about 1″ in thickness, called *furring strips*, are secured to the inside wall before the laths are nailed on, so as to provide a space between the brickwork and the finished inside wall and thus prevent dampness in the

A TWO SASH BALANCED WINDOW IN A BRICK WALL

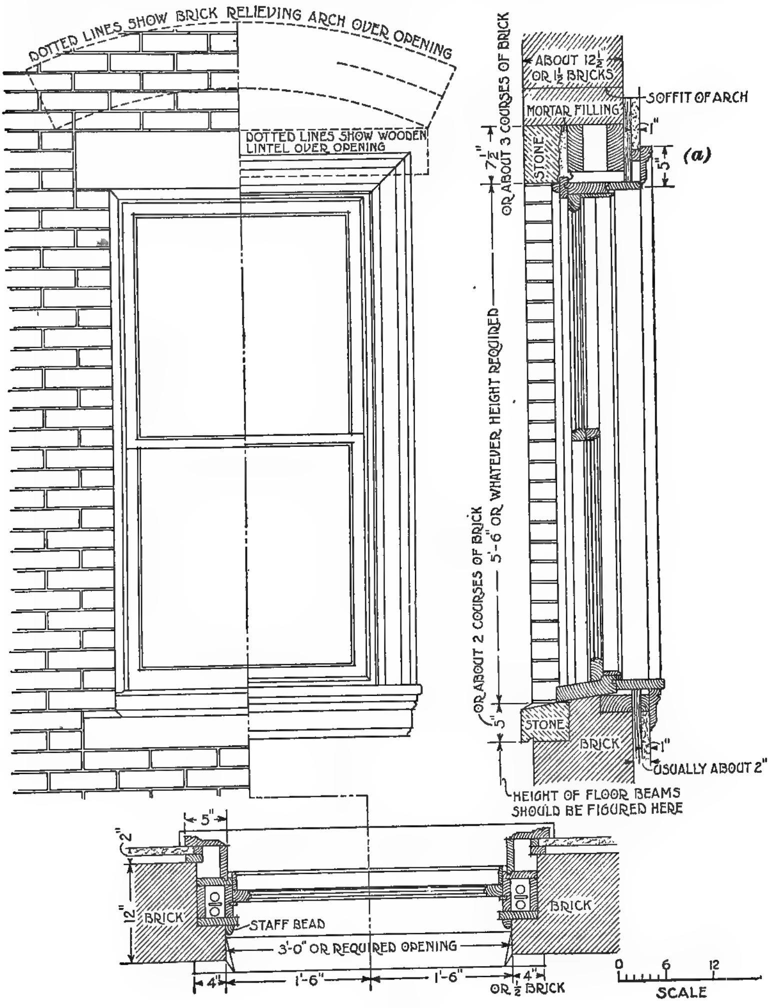

DOTTED LINES SHOW BRICK RELIEVING ARCH OVER OPENING
DOTTED LINES SHOW WOODEN LINTEL OVER OPENING
OR ABOUT 3 COURSES OF BRICK
7½"
5'-6" OR WHATEVER HEIGHT REQUIRED
OR ABOUT 2 COURSES OF BRICK
5"
ABOUT 12½" OR 1½ BRICKS
MORTAR FILLING
SOFFIT OF ARCH
1"
STONE
5"
(a)
STONE
BRICK
1"
USUALLY ABOUT 2"
HEIGHT OF FLOOR BEAMS SHOULD BE FIGURED HERE
5"
2"
12"
BRICK
BRICK
STAFF BEAD
3'-0" OR REQUIRED OPENING
4"
1'-6"
1'-6"
4"
OR ½ BRICK
0
6
12
SCALE

Fig. 11

house. As the yoke is usually made of common wood, it is not carried all the way through to the inside casing, but only to the inside of the brick-wall line, as shown in Fig. 12, at about which place a small piece of false casing made of hardwood is introduced to give a finished appearance from the stop-bead to the inside casing.

In the section shown at (*b*), Fig. 12, the outer edge of the wooden sill is seen resting on the stone sill, but the other constructions are similar. At (*c*) is shown a section through the weight box, illustrating how the box is completely framed for its particular purpose, and how the details of the inside finish of hardwood are fitted into it. On the outside a *staff bead* forms the finish between the woodwork and the brickwork. These staff beads vary in form but the style used here is simple and serviceable. The appearance of this window, both as inside and outside elevations, and the relation of the details to one another, as well as the dimensions necessary on a working drawing, are shown in Fig. 11.

42. Cellar Windows.—The detail of a cellar window is shown in Fig. 13, and, as will be observed, it is entirely different from the others in construction. This window is long and low, and is supposed to be hinged at the top to swing upwards against the ceiling. The opening in the brickwork is perfectly square, as shown in the plan (*a*), and the stone sill does not extend beyond the sides of the opening, but is slipped into place—this form of sill being known as a *slip sill.* The jambs consist of straight pieces of 1½″ stock rabbeted on the inner edge to receive the single sash, and the sill is embedded in mortar on top of the brick wall, and is also rabbeted to receive the sash when it swings into place.

43. In Fig. 14 is shown another form of a similar window somewhat more elaborate and so arranged as to receive a wire screen in front to keep out animals when the window is left open for ventilation. In this case, the stone slip sill is used as before, but the window is set in a stone wall instead of a brick wall, and the stonework comes only

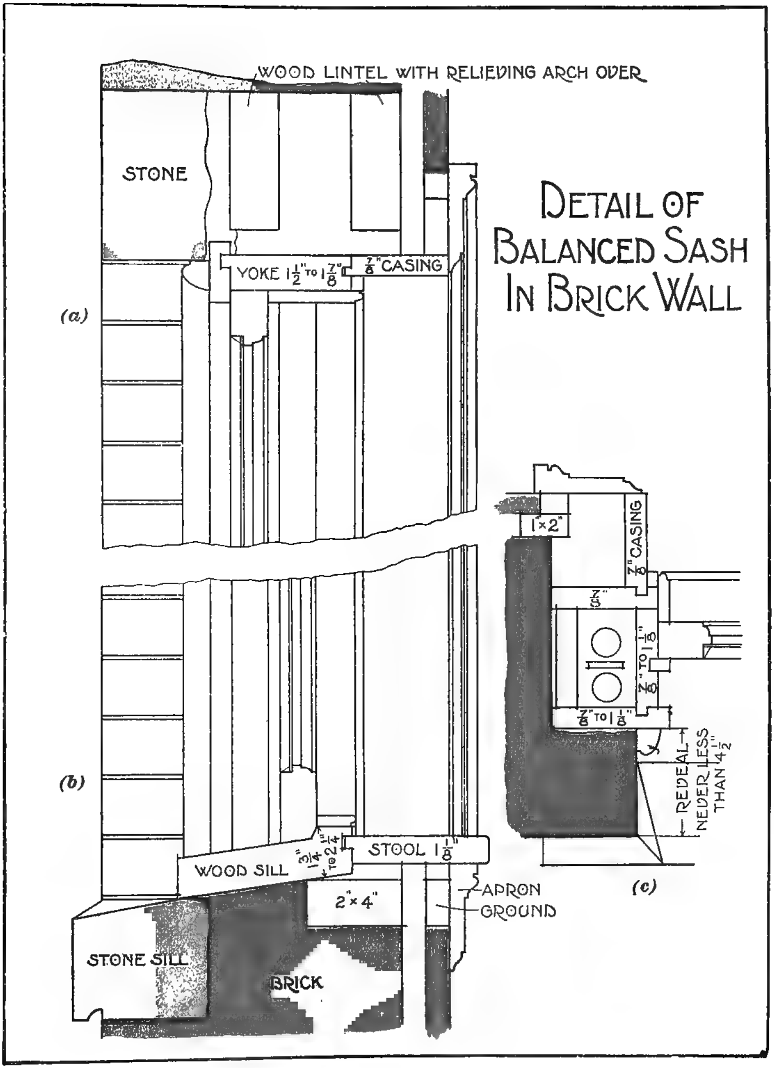

DETAIL OF BALANCED SASH IN BRICK WALL
WOOD LINTEL WITH RELIEVING ARCH OVER
STONE
YOKE 1½" TO 1⅞"
⅞" CASING
(a)
(b)
WOOD SILL
1¾" TO 2¼"
STOOL 1⅛"
APRON
GROUND
2"×4"
STONE SILL
BRICK
1"×2"
⅞" CASING
⅞"
⅞" TO 1⅛"
⅞" TO 1⅛"
REVEAL NEVER LESS THAN 4½"
(c)

Fig. 12

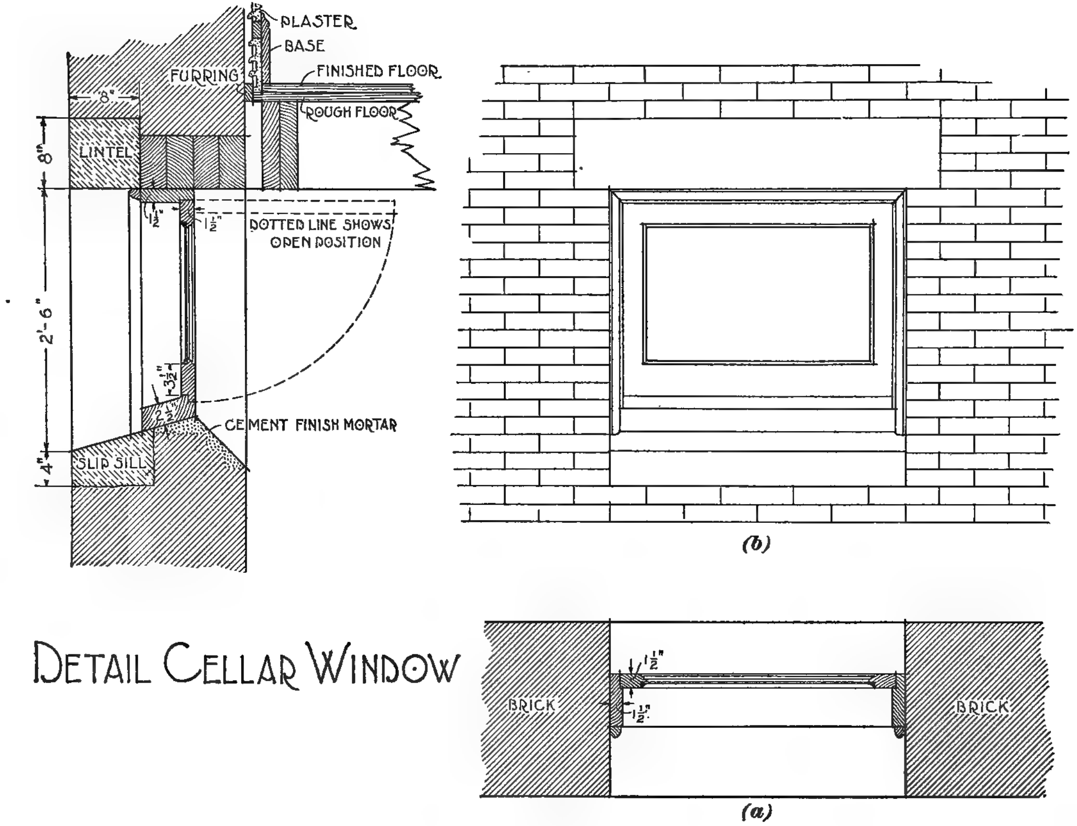

PLASTER
BASE
FURRING
FINISHED FLOOR
ROUGH FLOOR
8"
LINTEL
8"
2'-6"
4"
1½"
1½"
DOTTED LINE SHOWS OPEN POSITION
3½"
2½"
CEMENT FINISH MORTAR
SLIP SILL
DETAIL CELLAR WINDOW
(b)
BRICK
1½"
1½"
BRICK
(a)

FIG. 13

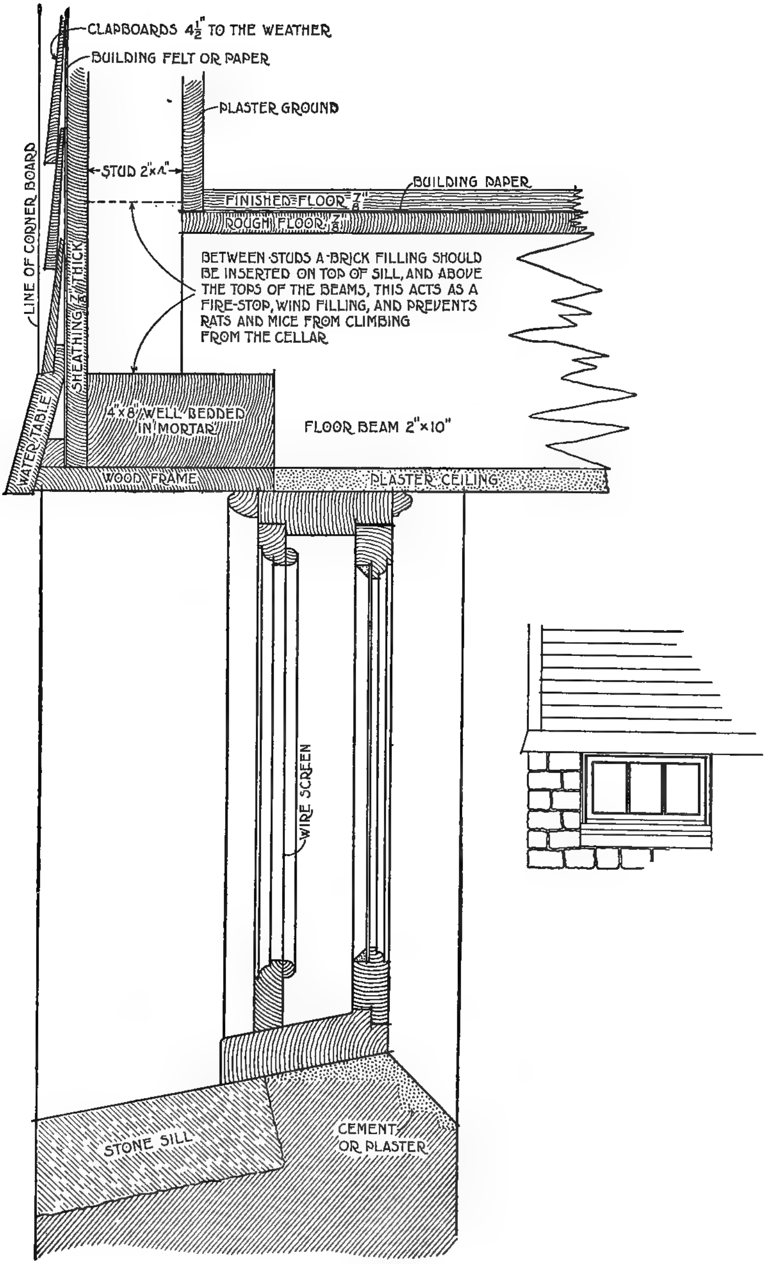
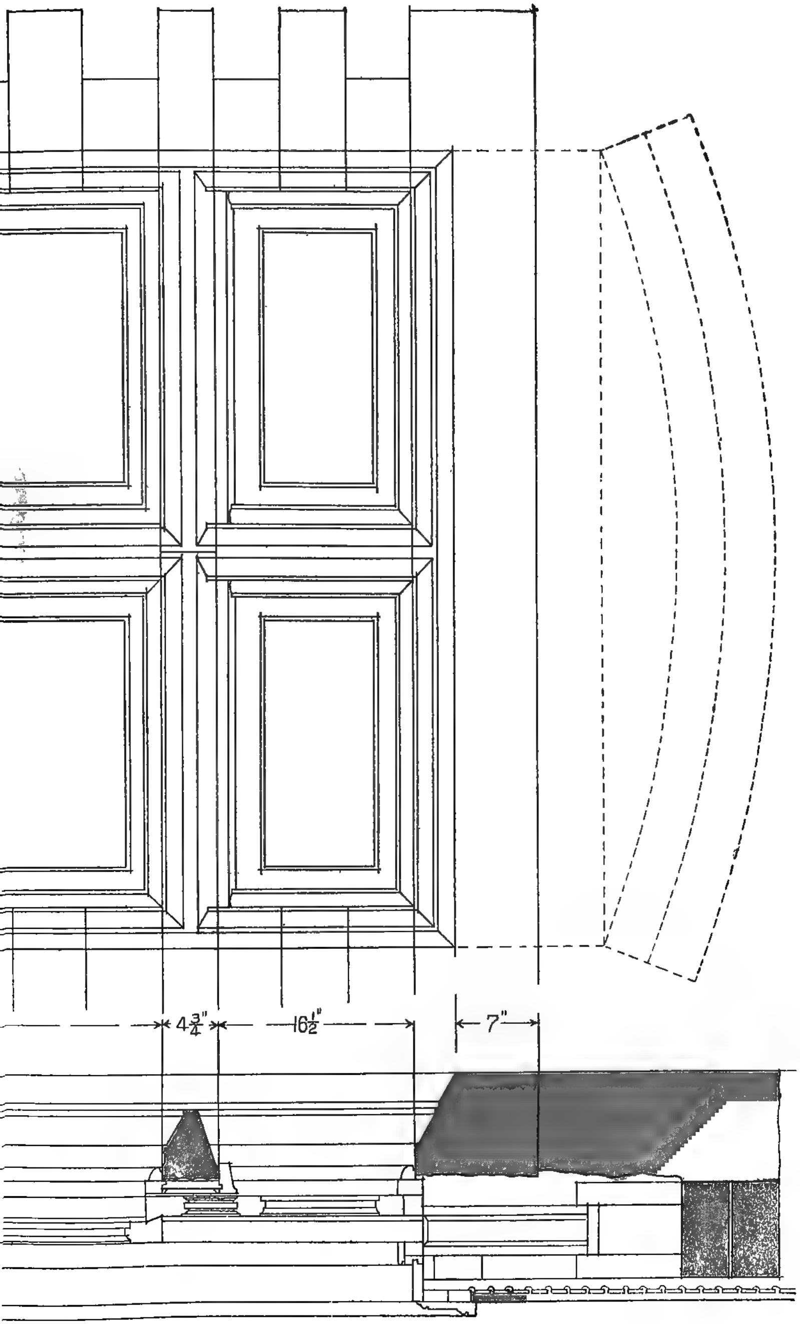

CLAPBOARDS 4½" TO THE WEATHER
BUILDING FELT OR PAPER
PLASTER GROUND
STUD 2"x4"
BUILDING PAPER
FINISHED FLOOR 7/8"
ROUGH FLOOR 7/8"
LINE OF CORNER BOARD
SHEATHING 7/8" THICK
BETWEEN STUDS A BRICK FILLING SHOULD BE INSERTED ON TOP OF SILL, AND ABOVE THE TOPS OF THE BEAMS, THIS ACTS AS A FIRE-STOP, WIND FILLING, AND PREVENTS RATS AND MICE FROM CLIMBING FROM THE CELLAR
4"x8" WELL BEDDED IN MORTAR
FLOOR BEAM 2"x10"
WATER TABLE
WOOD FRAME
PLASTER CEILING
WIRE SCREEN
STONE SILL
CEMENT OR PLASTER

FIG. 14


4¾"
16½"
7"

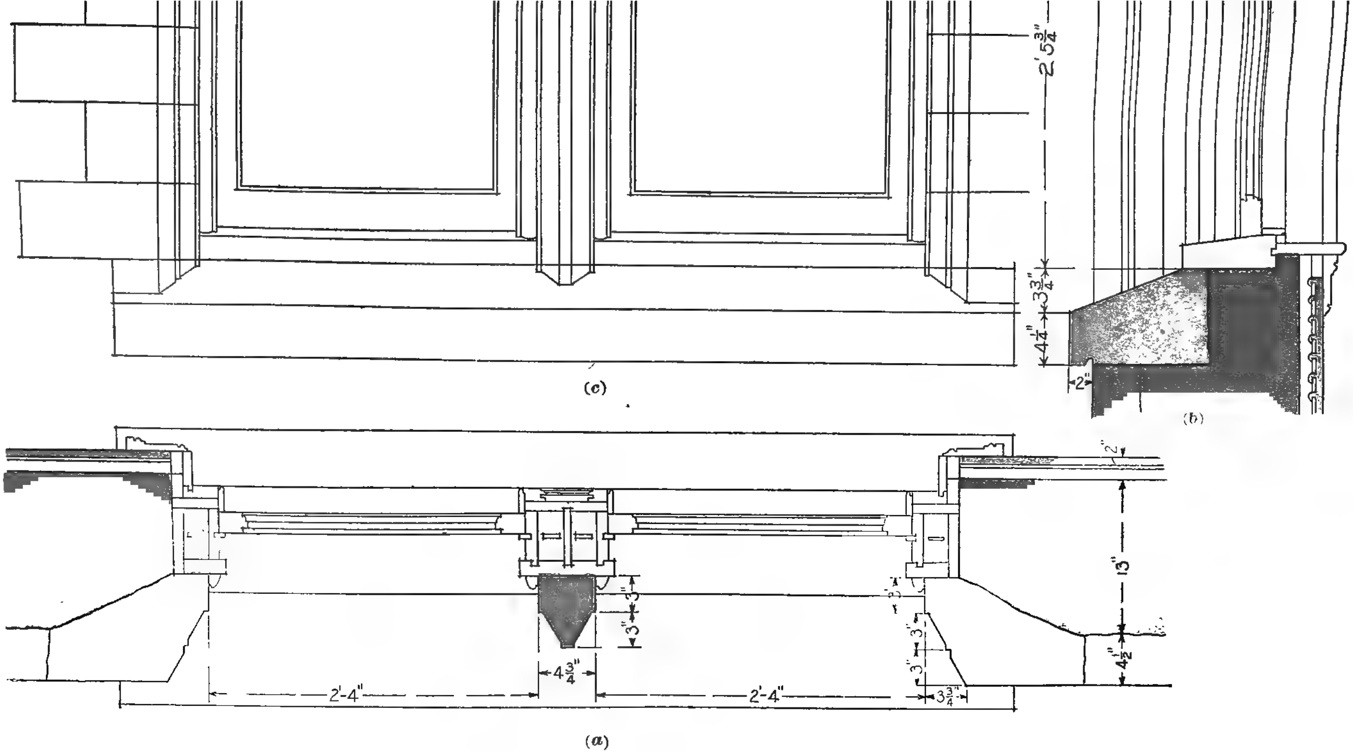


FIG. 15

to the top of the window. A 4″ × 8″ sill, placed over the opening carries the floorbeams, which are in this case plastered on the under side so as to give a finish to the interior. This construction would, of course, be similarly provided for in a brick wall.

44. Mullion Windows.—In Fig. 15 is shown the construction of a mullion window with stone trimmings. It will be observed that the wall of the building is of brick and has a 4″ facing of stone, and that this stone is carried around the reveals to the woodwork of the window. The stone mullion in the center of the window rests on the sill shown in the plan (*a*), and behind this mullion is framed the wooden weight box, which is similar to that shown in Sheet II of Exercise III. In section (*b*), the transom bar is the same depth as the mullion, and behind it the upper sash is framed in order to show a panel when the window is closed. The lower sash is larger than the upper one, behind which it slides when pushed up into the pocket above; the latter extends up between the two timbers forming the wooden center or the arch of brick. In the elevation (*c*) is shown the general appearance of this window from the outside, being trimmed each side with quoin stones alternating in width. The sash is perfectly plain, but could be elaborately molded if desired, as could also the mullion and transom bar.

In Fig. 16 is shown an enlarged section through the mullion, and in Fig. 17, the construction of the panel back of the transom bar. The meeting rails have a shoulder between them as they come together, which form of construction is

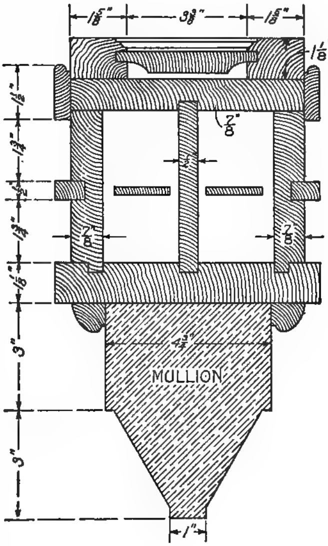


FIG. 16

desirable in large windows, as there is likely to be less draft through this point. A simple panel is framed at the bottom of the upper sash showing the interior when the window is closed; but when this sash is dropped down, the panel, which is framed upon the mullion, shows through the window and presents a pleasing appearance on the inside. At the back of the wooden mullion containing the weight box, as shown in Fig. 16, a similar panel is framed so that it may be seen from the inside of the room. If this mullion window is used in a square opening in the wall, and it is desired to make all these details of wood,

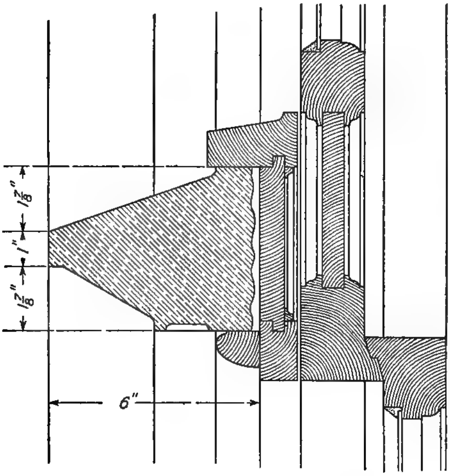


FIG. 17

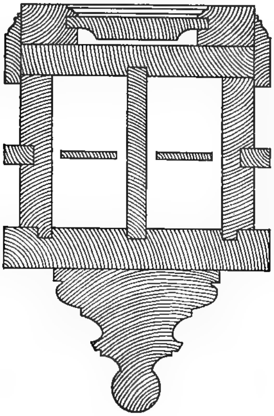


FIG. 18

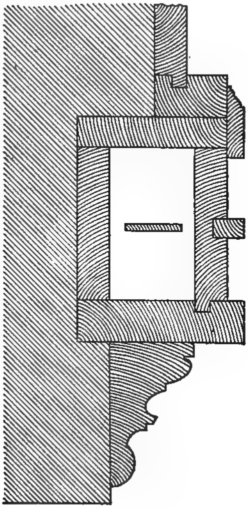
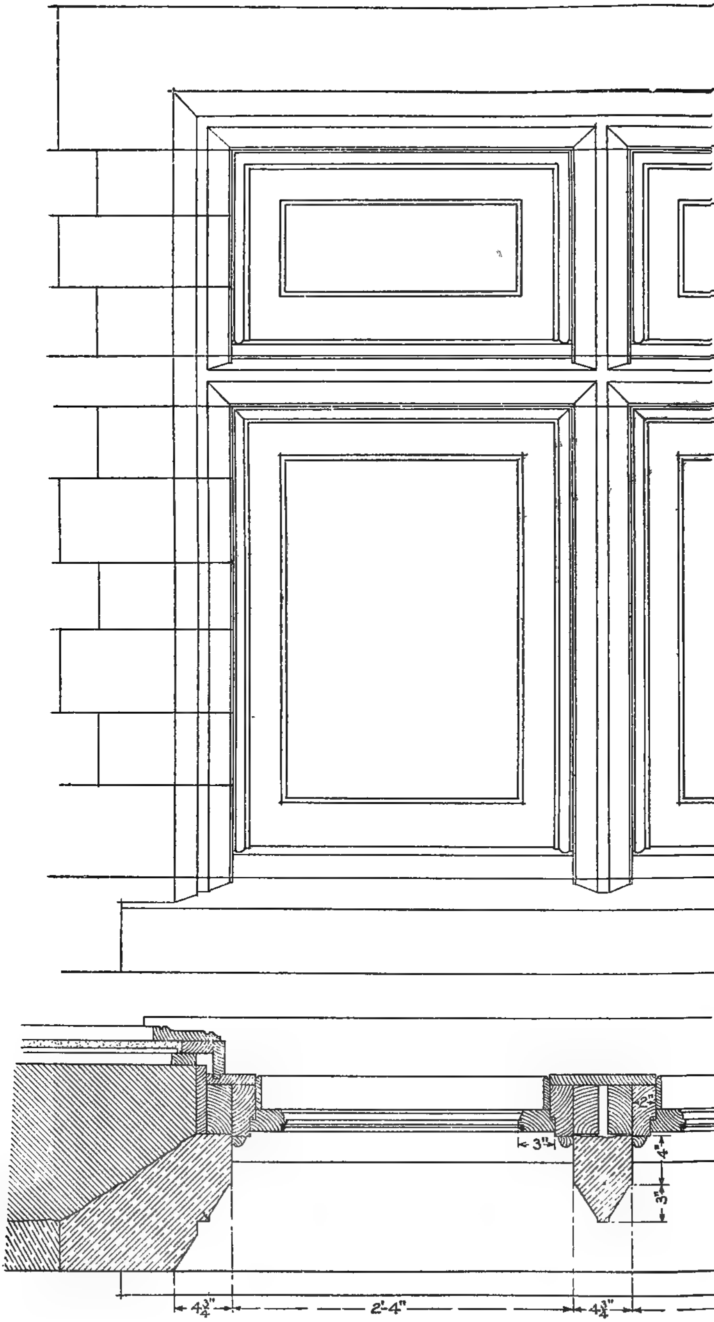
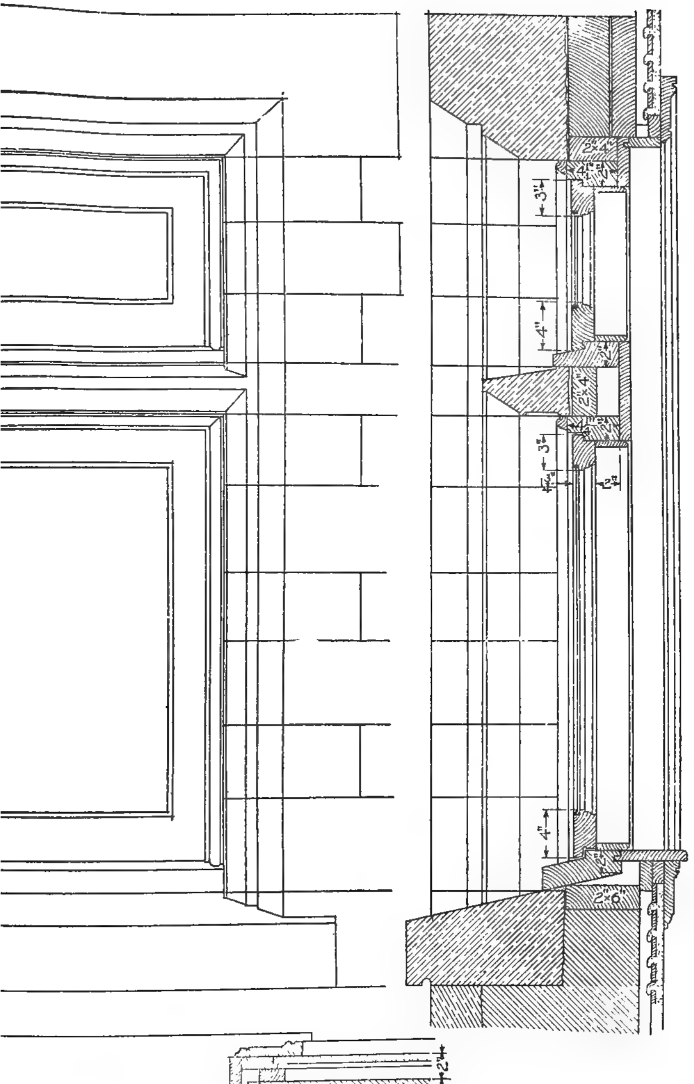


FIG. 19



FIG


2"x4"
4½"
2"
3"
4"
2"
2"x4"
4"
2"
3"
1½"
4"
2"
2"x6"
2¼"
13"
4"
2'-4"
4¾"

then the mullion can be molded somewhat as shown in Fig. 18, while the sides of the opening can be treated as in Fig. 19.

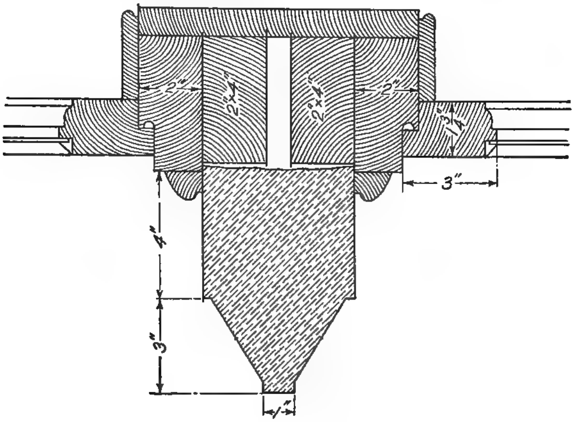


FIG. 21

45. Casement Windows.—Sometimes, it is desired to have a window hinged at the top or sides so as to swing outwards or inwards. Such a window is called a **casement window,** and is constructed as shown in Fig. 20. These windows are very difficult to make weather-tight, as driving rain will work around the joints of the best of them; but the form shown in Fig. 20 is inexpensive and gives satisfaction if not placed in an extremely exposed position. The details of the mullion and transom bars are shown in Figs. 21 and 22, and the arrangement of these details for a frame building in Fig. 23.

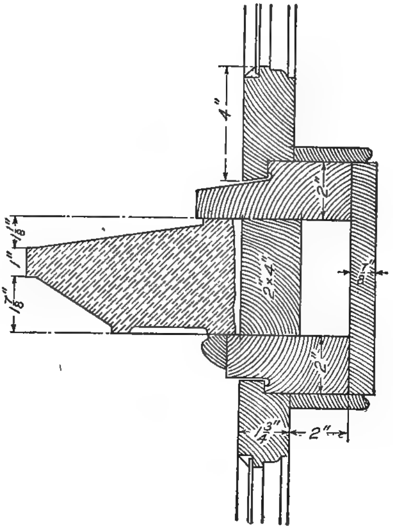


FIG. 22

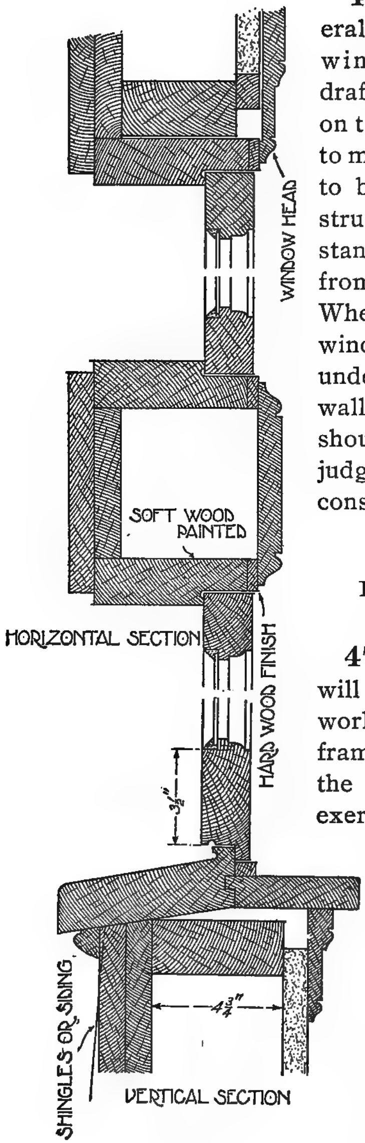


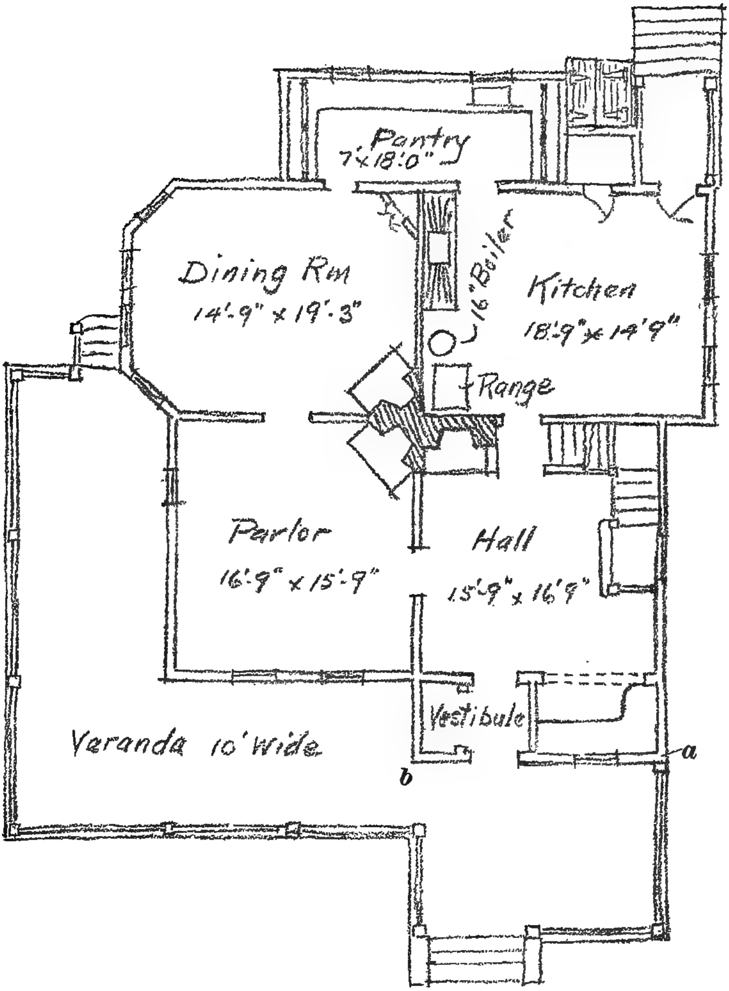
FIG. 23

46. This completes the general description of such forms of windows as the architectural draftsman is most frequently called on to consider. It is not necessary to make all these drawings in order to become familiar with the construction, as different circumstances will necessitate variations from the construction shown here. When cases arise, however, where windows are to be introduced under certain conditions into the walls of a building, these forms should be consulted in order to judge what particular system of construction is best suited.

EXERCISE IV, TITLE: FIRST-STORY PLAN

47. The next seven exercises will consist of a set of plans or working drawings for a two-story frame suburban dwelling. It is the intention, in laying out this exercise, that the drawings be proceeded with as closely as possible along the same lines that would be followed in an architect's office.

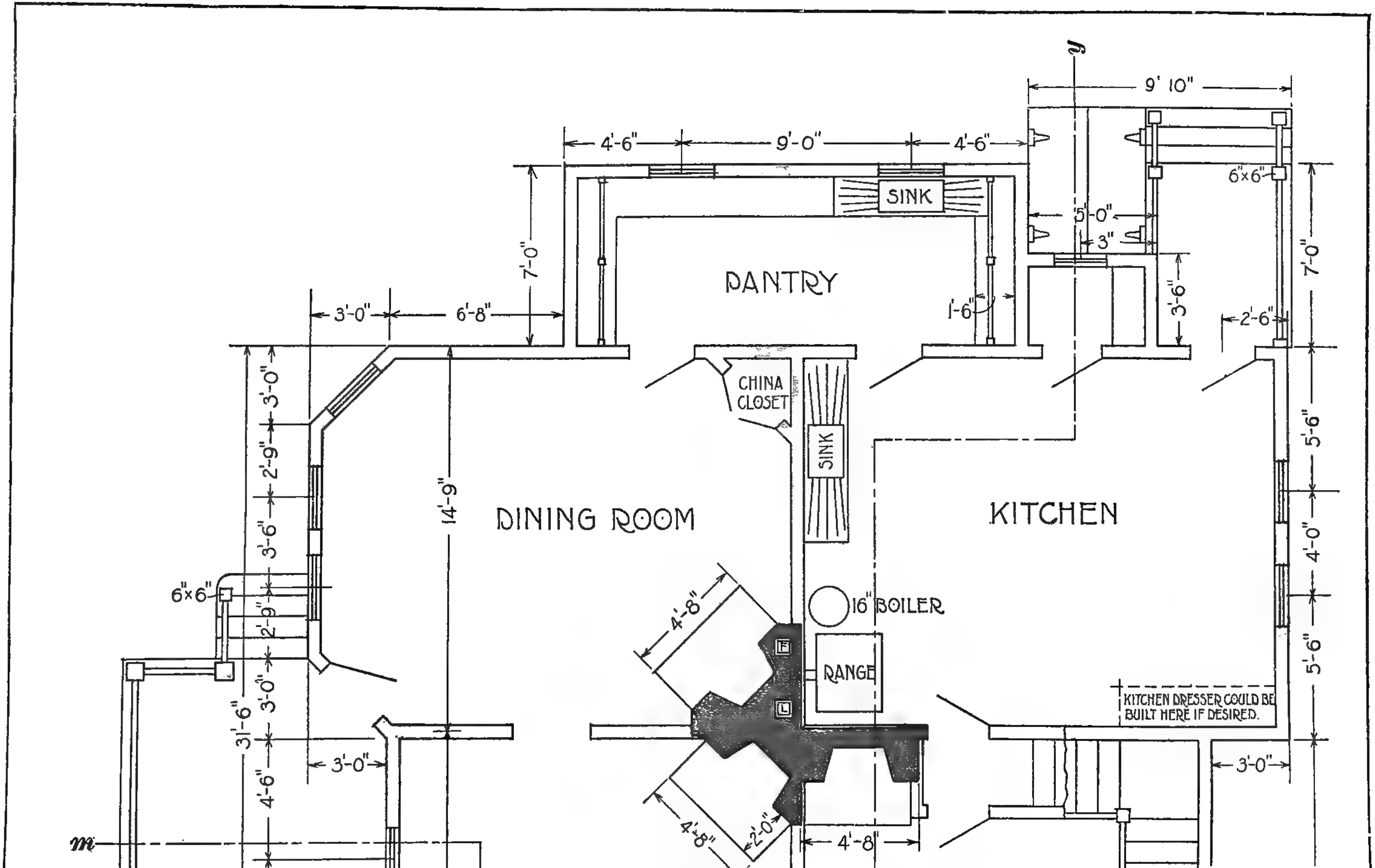
In practice, the architect works out the general scheme for his plans in a small sketch, such as is shown in Fig. 24, and on this sketch marks the sizes of the rooms and the name and purpose of each.



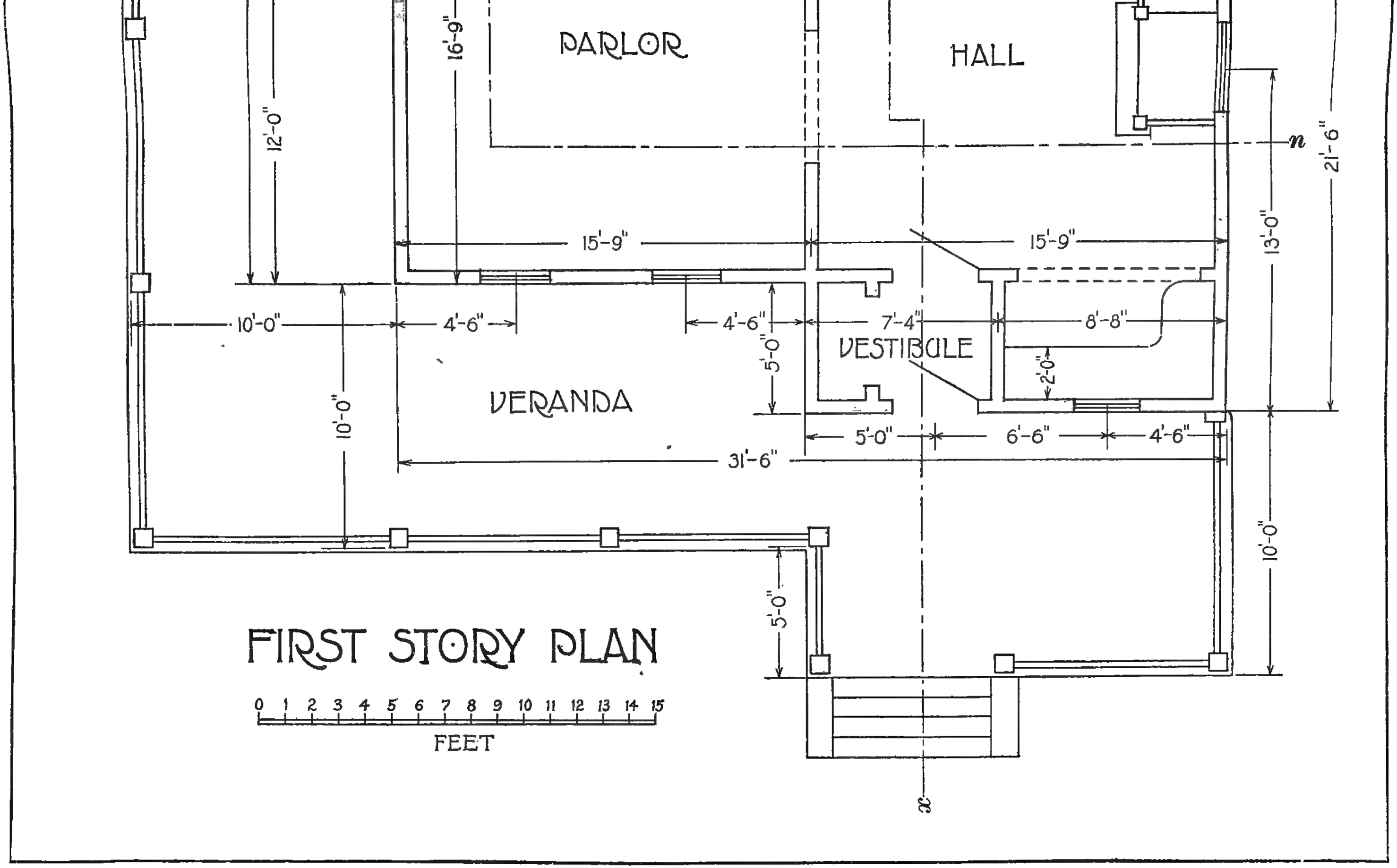
First Floor Plan.

FIG. 24

EXERCISE IV



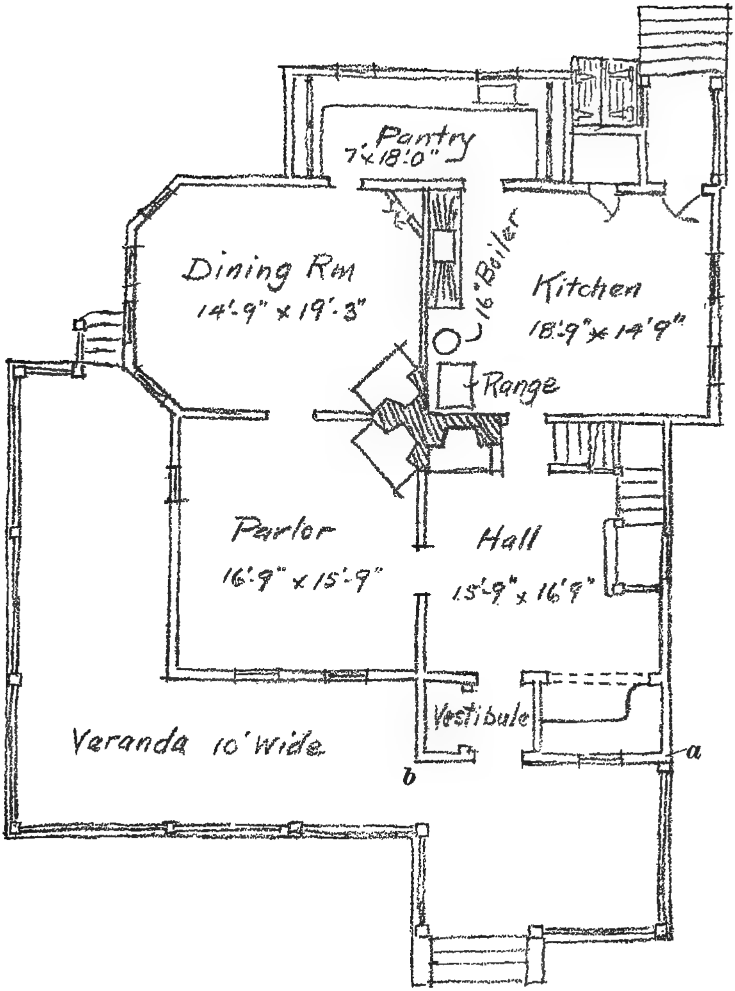
h
9' 10"
4'-6"
9'-0"
4'-6"
SINK
6"×6"
5'-0"
3"
7'-0"
PANTRY
3'-6"
1'-6"
2'-6"
3'-0"
6'-8"
7'-0"
CHINA CLOSET
SINK
5'-6"
KITCHEN
4'-0"
DINING ROOM
14'-9"
3'-0"
2'-9"
3'-6"
6"×6"
2'-9"
16" BOILER
4'-8"
F
RANGE
L
5'-6"
KITCHEN DRESSER COULD BE BUILT HERE IF DESIRED.
3'-0"
31'-6"
3'-0"
3'-0"
4'-6"
4'-8"
2'-0"
4'-8"
m



Date

Time consumed in executing this sheet

Name of Student, Class Letters and Number



First Floor Plan.

Fig. 24

The draftsman then takes the rough sketch and lays it out to $\frac{1}{8}''$ or $\frac{1}{4}''$ scale, according to circumstances. If the scheme for the plan has been carefully studied out by the architect, and he knows that the rooms and other details will come just where intended, the draftsman can go ahead with the $\frac{1}{4}''$ scale drawing. But if the plan is in very rough shape—about as shown in Fig. 25—much time can be saved by making a preliminary sketch on a scale of $\frac{1}{8}''$ to the foot. The architect usually makes a set of $\frac{1}{8}''$ scale preliminary sketches to submit to his client for approval before the working drawings of the building are prepared, as changes in the plan are much more economically made on the $\frac{1}{8}$-scale drawings than on the $\frac{1}{4}$-scale, or working, drawings, and it is always better to be sure that everything is all right on the preliminary sketch before work on the final plans is commenced.

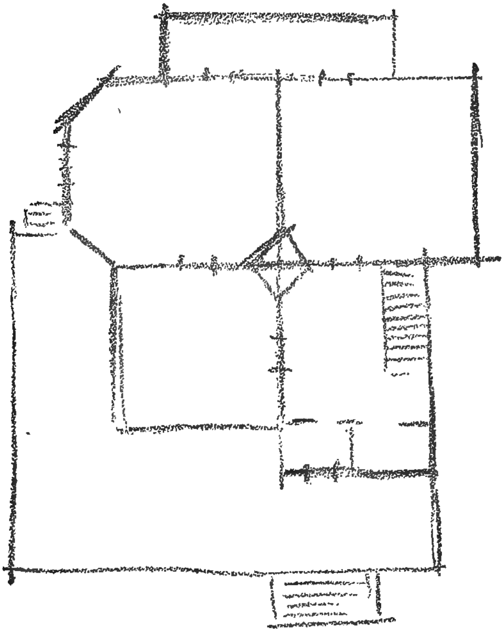


FIG. 25

48. Now, assume that Fig. 24 is a preliminary sketch, and that it is to be made into a working drawing such as shown in Exercise IV. In laying out a plan in this way, it is best to locate the general points of the building first, and then draw in the most difficult and important details, namely, the stairs and chimneys. This exercise should be drawn on a large sheet of paper, 14 in. × 18 in., with a border line 13 in. × 17 in. and proceeded with as follows:

Turn the drawing board vertically and locate the corner of the house *a*, Fig. 24, $4\frac{1}{4}''$ above the lower, and $1\frac{1}{2}''$ to the left of the right, border line. Then, with the $\frac{1}{4}''$ scale lay off 16′ 0″ to *b*, and mark each of the points *a* and *b* with a cross drawn with the **T** square and triangle, as shown in Fig. 26. Each side of these cross-marks represents the direction of one side of the house, and their intersection represents the point where a wooden stake would be driven in laying out the house on the ground before excavating for the foundations. Now, proceed to "stake out" the rest of the plan, locating *c* 5′ 0″ above *b*, and *d* 15′ 6″ to the left of *c*. The ends of the center line *e′p* of the transverse partition may now be drawn 16′ 9″ back of *c*. The point *e′* at one end of this line is 3″ back of the intersection of the side of the house *de* and the diagonal corner of the bay window *ef*. The point *f* is 3′ 0″ back of *e*, at an angle of 45° to the left, and the point *h* is directly behind *e′* at a distance of 14′ 9″. Locate *i* 6′ 8″ to the right of *h*, and place *k* 7′ 0″ back of *i*. Now, return to *a* and from it locate *p* directly behind *a* on the end of the line *e′p*. Stake out *o* 3′ 0″ to the right of *p* and 3″ in front of a line drawn through *e′p*. Locate *n* at the intersection of the two sides of the house *on* and *hn*. Then, *m* is 9′ 10″ to the left of *n*, and *l* is at the intersection of the side and rear walls of the pantry.

If these measurements are staked out carefully, the plan should work out exactly, and the sides of the house may be drawn in, showing the thickness of the walls as 6″. The longitudinal and transverse partitions should now be drawn through the house from *e* to *o* and *b* to *j*, but no attempt should yet be made to show any door or window openings.

These details are easily placed after the more difficult problem of stairs is solved. As soon as the general plan is laid out, proceed at once with the stairs.

The ceiling in the first story is to be 9′ 6″, and this with the thickness of the floor and beams will make the rise from the first to the second story about 10′ 6″, or 126″. If the rise of each step is assumed to be *about* $7\frac{1}{2}''$, it will be found that not less than seventeen risers are required. Seven of these are arranged in the hall leading up to the second landing, and the remainder lead from the second landing to the second story.

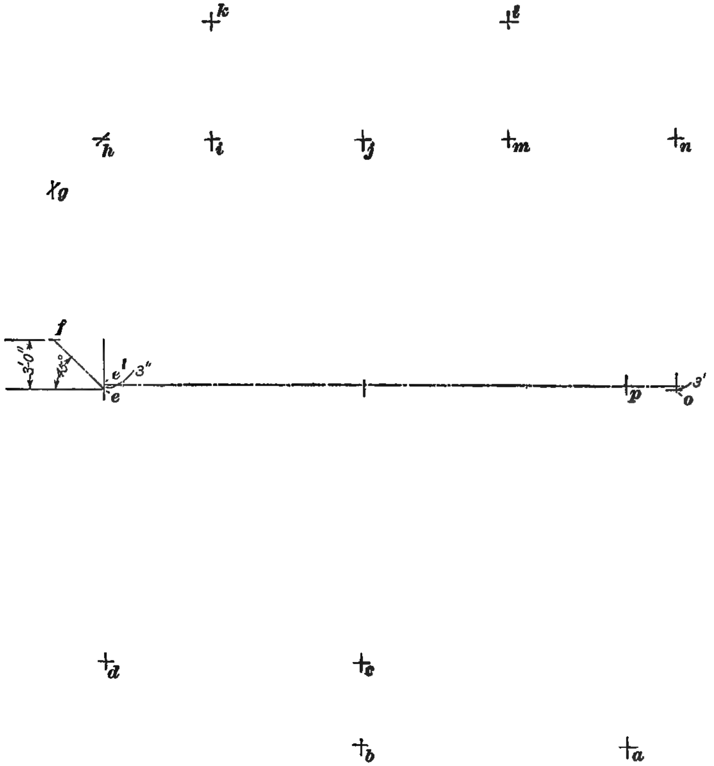
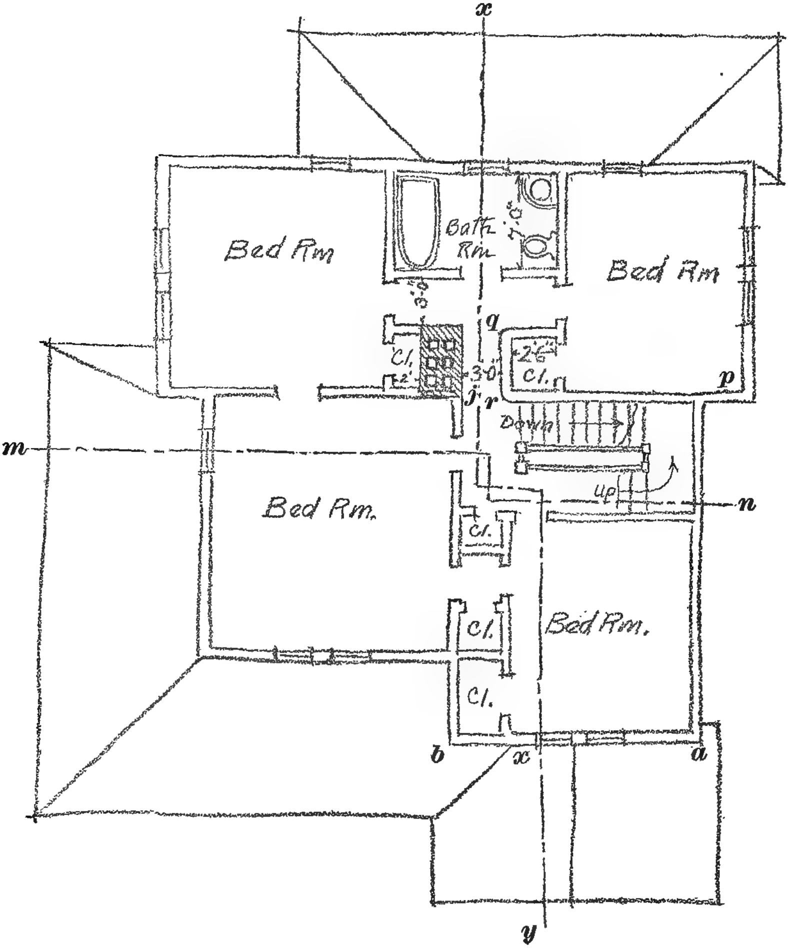


FIG. 26

49. A glance at the second-story plan, Fig. 27, will show that the partition *b j* is directly over the partition *b j* in the first story, and that the partition *q r* is 3′ 0″ to the right of it to make a passageway to the bathroom. Therefore, the head of the stairs cannot extend beyond the point *r*, but it



Second Floor Plan.

FIG. 27

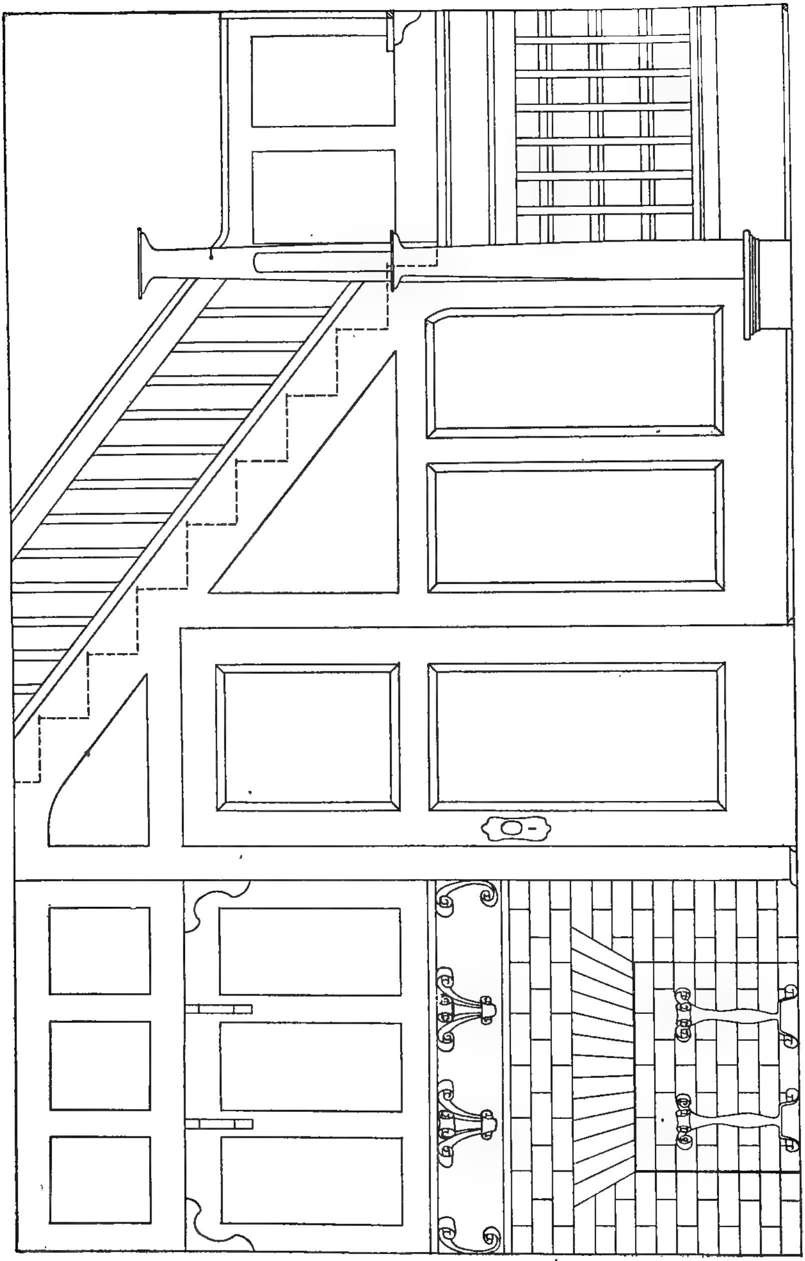


FIG. 28

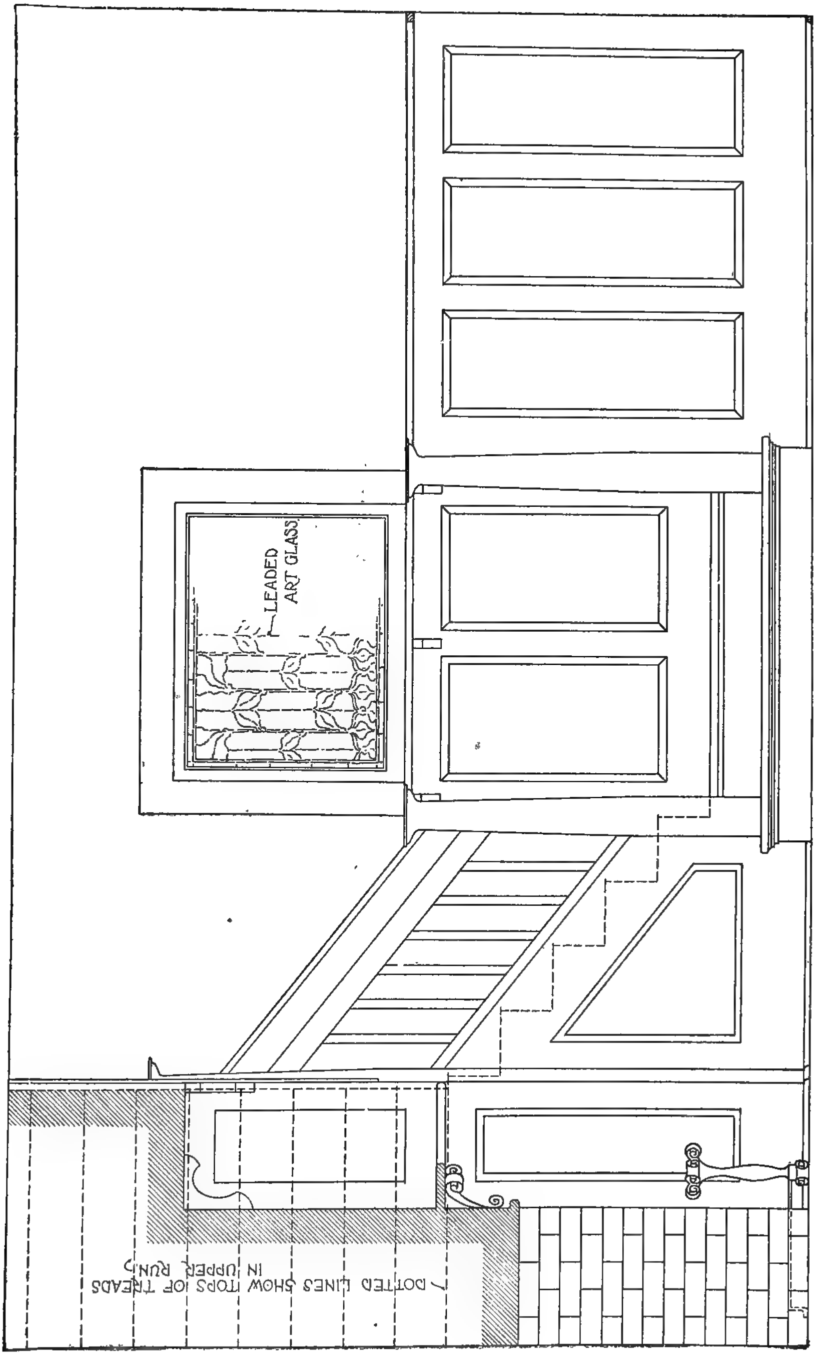

LEADED ART GLASS
DOTTED LINES SHOW TOPS OF TREADS IN UPPER RUN

FIG. 29

may be placed anywhere between *r* and the landing below. The run of each step is 10″ in width and nine of them are required from the landing to the second floor; therefore, the line of the last riser of the flight should be located 90″, or 7′ 6″ to the left of the landing. However, if desirable, there could be less than nine risers in this run of steps and more than seven in the lower run, or less in the hall and more in the upper run, but the present arrangement is better, as will be learned later.

In planning stairways great care should be exercised to secure headroom at all points; therefore, the stairway should always be worked out carefully in detail at first and the minor rooms of the house grouped accordingly. By *headroom* is meant sufficient height above each riser for a person to ascend or descend the flight freely. Several stair schemes may be planned before a suitable one is found.

50. In Figs. 28 and 29 are shown two elevations of this stairway, the former showing the hallway run of seven risers to the landing. In Fig. 30 is shown a section through the riser and tread of the stairway in order that details may be clearly understood. It will be observed here that the *tread* of the step is considerably longer than the *run*. The run is measured from the face of one riser to the face of the next, but the tread projects considerably beyond the face of the riser. The extreme edge of the tread is called the *nosing*.

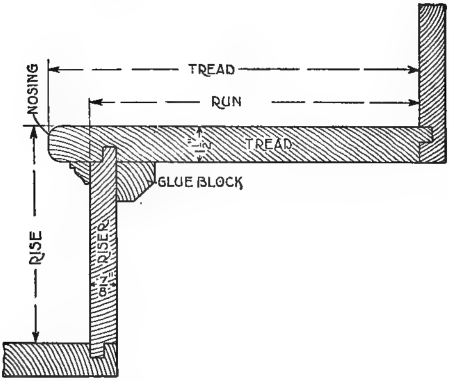
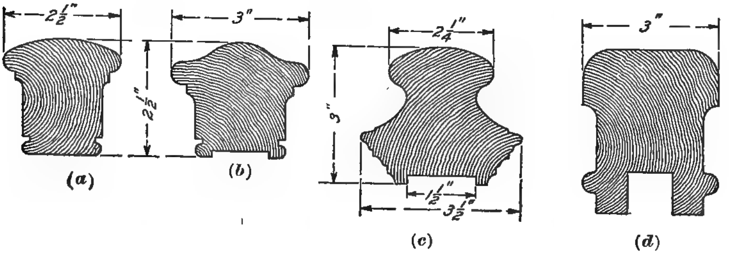


Fig. 30

Now, return to the drawing of the stairs on the plan. Make the width of the stairs 3′ 0″ to the outside of the rail.

Draw the upper landing 3′ 0″ square, and then show four treads about 10″ or 11″ wide from the landing to the platform. The platform is 3′ 0″ wide and 4′ 3″ long to outside of the rail, and there is one tread beyond it extending into the hall. The posts, or newels, are 6″ square, elevations of these posts and of their position relative to the stairs being shown in Figs. 28 and 29.

Hand rails vary in size and form, but as their fundamental purpose is to provide a support or guide for the hand, it is essential that the top should not be too wide to grasp conveniently. In Fig. 31 are shown four common forms with their dimensions. These dimensions can be varied considerably, but the top portion should not exceed 4″ in width, as the rail would then be too large to take hold of. The rail at the side of the stairs is of the form shown in Fig. 31 (*d*). It is 3″ wide, and enters the side of the newels at their center lines.



(*a*) (*b*) (*c*) (*d*)

FIG. 31

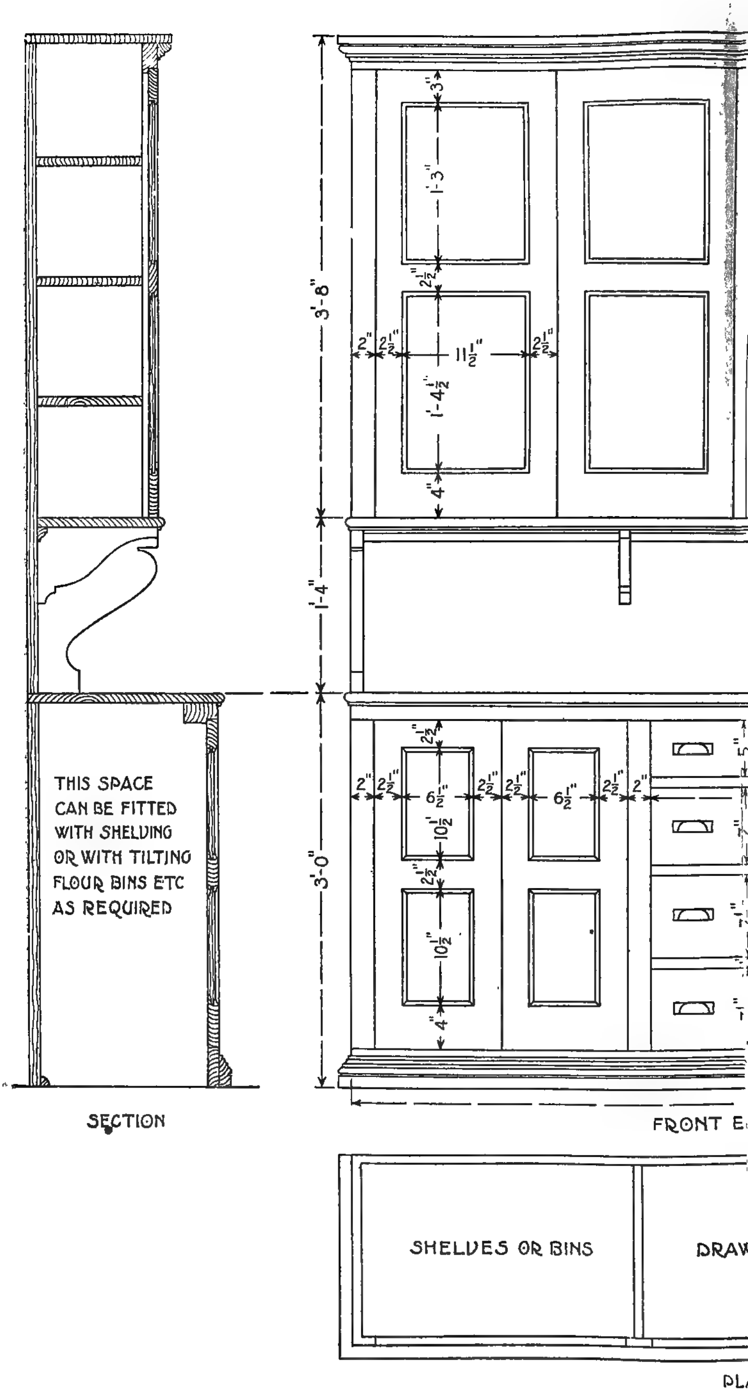
51. Having finished the stairs, the fireplace in the hall may now be considered. The fireplaces are grouped in the center of the house, as by this means all may be vented into one chimney—a very economical arrangement. However, a door is required from the kitchen to the hall, and as this door must be placed so as to give headroom under the stairs, it will be well to consider the elevation of the stairs in Fig. 29 once more. This shows the stairway on the hall side, where it will be seen that a door 7′ 4″ high cannot be placed farther to the right than the sixth riser from the landing. Draw this door opening in the kitchen partition 2′ 6″ wide, and allow a trim and casing of 6″ between the door and the chimney breast. Make the fireplace opening 2′ 8″ wide in front, 2′ 4″ wide at the back, and 1′ 4″ deep, and allow a 12″ chimney breast each side. The partition from the chimney breast to the outside of the stair run marks the edge of the hearth and partly encloses the fireplace in an alcove. The stairs to the cellar descend under the long run of the main stairs, and an irregular line indicates the main run as broken off so that the position of the cellar run may be seen.

The fireplaces in the parlor and dining room extend diagonally across the corners of these rooms, and are proportioned so that the openings are 2′ 8″ wide in front, 2′ 4″ wide at the back, and 1′ 4″ deep, and the chimney breasts 12″ wide. The hearths in front of the fireplaces are 2′ 0″ wide and long enough to extend entirely across both chimney breasts.

52. Kitchen sinks vary in size from 12″ to 28″ in width, and from 16″ to 78″ in length. The one shown here is 14″ × 24″, and there is a draining board extending about 2′ 6″ each side of it. Grooves to carry off the superfluous water are cut in this board, and these grooves are indicated on the plan by radiating lines.

After locating the sink and its draining board, the door into the pantry may be placed so as to leave about 6″ between the door and the edge of the board. The shelf or table in the pantry is 2′ 0″ wide across the back of the pantry and 1′ 6″ on the sides, with a small sink in the middle as shown. This sink is 20″ × 30″ and is made of porcelain. Over the 18″ shelf on each end of the pantry is a china closet enclosed with glass doors. These doors and the posts between them are 1½″ thick. A detail of this closet is shown in Fig. 32. A china closet is shown across the corner of the dining room, thus making that room symmetrical on all four corners.

53. The vestibule may now be drawn with an alcove closet on one side, where umbrellas, etc. may be placed.


THIS SPACE CAN BE FITTED WITH SHELVING OR WITH TILTING FLOUR BINS ETC AS REQUIRED
SECTION
3'-8"
1'-4"
3'-0"
3"
1'-3"
2½"
2"
2½"
11½"
2½"
1'-4½"
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2"
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2½"
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10½"
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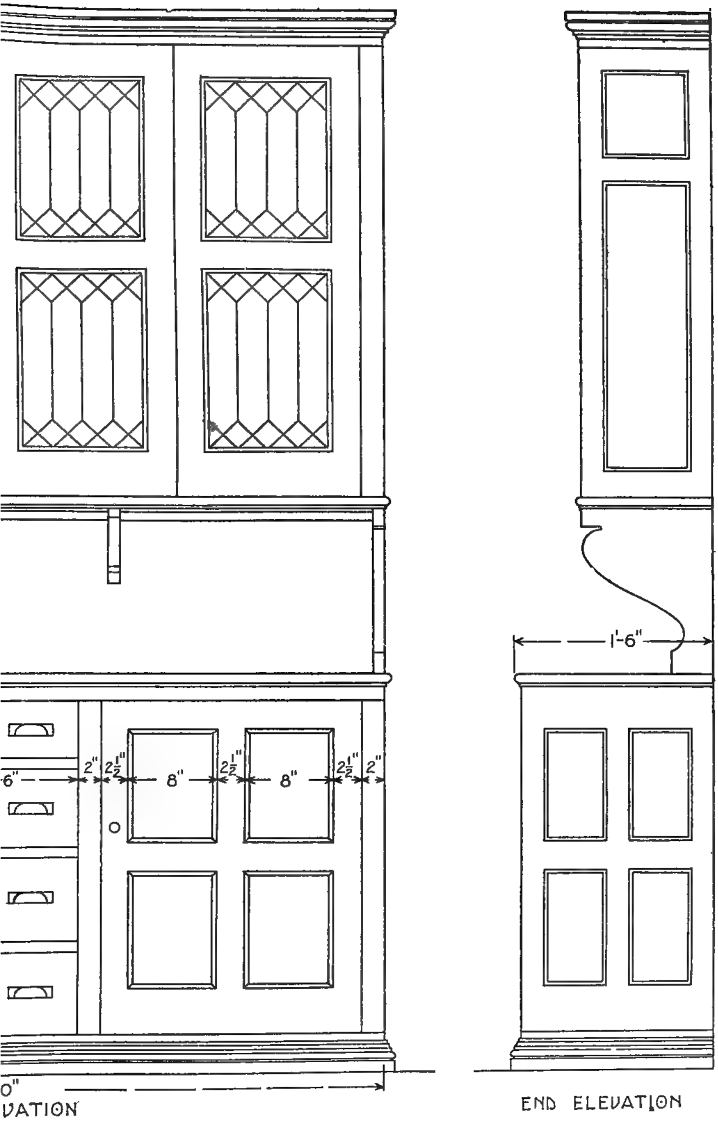
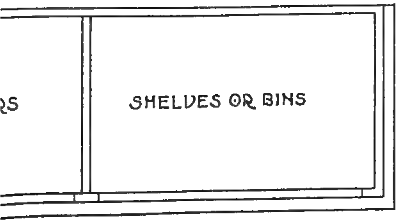
4"
FRONT E
SHELVES OR BINS
DRAW
PLA

Fig.





DESIGN FOR KITCHEN PANTRY OR DRESSER

0 6 12
SCALE

The vestibule-door opening and the front door are 3′ 4″ in width. In the corner of the hall between the vestibule and the outside wall is built a seat 24″ wide, as shown, and an arch, indicated by the dotted lines, converts this corner into an alcove.

The veranda is 10′ 0″ wide, and extends around two sides of the house, as shown. The posts are 8″ square and are spaced as shown.

The window and door openings should now be put in place, centering them as nearly as possible in the walls of the rooms or placing them well to one end, so that there will be no danger of their appearing "just out of center." The designing of the elevations has much to do with the grouping of the windows, so their final arrangement in the plan should be left until the elevations are finished. Draw them in about as shown, however, as they will be considered again when the elevations are drawn. All door openings on this plan, other than vestibule and front door, are 2′ 6″ wide. All window openings are 2′ 6″ to 2′ 10″ wide, except the stair landing window (3′ 6″ wide) and the kitchen closet window (2′ 0″ wide).

54. Every working drawing should be carefully figured; that is, the dimensions of each detail should be as marked or described so that there should be no difficulty in determining its size and place. Every set of working drawings is accompanied by a set of *specifications* when it is sent to the builder. On this exercise the principal dimensions of the house are indicated, but all the minor dimensions must be filled in from estimated calculations, and it should be remembered that all dimensions, when added up, must agree with the gross dimensions for the same parts, and that all measurements should be carefully checked by the scale. The specifications are intended to instruct the builder as to what the materials are and how they are to be put together and finished.

Color in the walls of the building with burnt sienna when woodwork is represented, and with Indian red, or other similar red pigment, when the brick fireplace and chimney are indicated. The exercise should be finished and lettered, as before. A pencil tracing or copy should be retained for the reason that the subsequent plans are based upon this one. Then the finished exercise may be sent to the Schools for correction.

EXERCISE V, TITLE: SECOND-STORY PLAN

55. In working up the second-story plan of a house, the architect usually covers the first-story plan with a piece of tracing paper, and works out the principal features directly over those underneath. The positions of such unchangeable features as the stairs and chimneys can thus be transferred to the second-floor drawing, and the minor partitions, etc. arranged accordingly. A glance at Fig. 27 will illustrate how much the subdivision of the second floor is dependent on the one below. It is considered good planning to have partitions come over each other whenever possible, and in this case the partitions *b j* and *r p* are directly over the partitions in the first story. The bathroom is so placed that its plumbing arrangements will be over those of the kitchen, thereby making an economical run of pipes.

The two principal bedrooms are rather large in this plan, but the subdivision of this space into three rooms would not be of any great advantage, as there is opportunity to finish other rooms in the attic if desired. The large bedrooms are attractive and render the plan much more satisfactory than the long narrow chambers that would result from the suggested subdivision. Details of this character should always be taken into consideration in planning a house, as much space is frequently wasted in the endeavor to crowd into a given space more apartments than is advisable, especially when other rooms are available in the attic.

56. In drawing the second-story plan, locate the corner *a* precisely as in the first-story plan, and then proceed with the entire outside walls of the house. The principal partitions are directly over those in the first floor, and as the position of the stairs has already been determined, draw in the stairway, leaving 4′ 6″ between the top step and the partition *b j*. The passage, or hall, is 3′ 0″ wide and influences the size of the closets for the bedrooms. The bathroom is proportioned to accommodate the fixtures therein, and the fixtures are located to suit the plumbing arrangements below. The bathtub is 2′ 6″ wide by 5′ 6″ long, and the room is therefore made 7′ 0″ wide. The closets in the bedrooms are 3′ 0″ wide and 2′ 6″ deep, and carrying these partitions down to limit the bathroom makes the bathroom 10′ 6″ long. The roof over the veranda extends 12″ beyond the floor lines, and thus projects 11′ 0″ from the house line. The roof over the pantry projects a similar distance over the side walls of the pantry and back porch, and is therefore 8′ 0″ wide by 30′ 0″ long. The diagonal lines from the outer corners of the roof to the house line are lines of intersection of the roof slants, and will be better understood when the elevation and roof plan have been studied. Lay out the windows and space them about as shown in the sketch, Fig. 27. All door openings should be about 2′ 6″ wide and all window openings about 2′ 6″ to 2′ 10″ wide. These sizes may vary according to local building conditions, etc.

The slab of the basin in the bathroom is 24″ × 30″, while the bowl is 16″ × 21″ and elliptic in shape. Oval wash basins are usually made 14″ × 17″, 15″ × 19″, and 16″ × 21″ in size, and round basins are made 10″, 12″, 13″, 14″, and 16″ in diameter. Basin slabs of marble are usually 20″ × 24″, 20″ × 30″, 22″ × 28″, and 24″ × 30″, the last being the most common size. They should be 1¼″ thick, and have a countersunk top and molded edges where exposed. The water-closet seat is 16″ × 23″, and stands 17″ above the floor. The chimney contains six flues, each 8″ × 8″ with 4″ tile flue linings instead of brick partitions between them. These six flues connect with the three fireplaces and the range in the first story, and with the furnace and laundry stove in the basement, or cellar.

In Fig. 43 is shown the plan (*a*), the elevation (*b*), and the section (*c*) of an ordinary fireplace and chimney breast.

The dotted lines in the elevation show the arrangement and direction of the flues. At (*d*) and (*e*) are shown plans of the chimney above the roof, (*d*) being the plan when terra-cotta linings are used in the flues surrounded by 4″ brick walls, and (*e*) showing the same chimney with brick partitions between the flues.

This exercise is worked up from the drawing of the first-story plan. No completed drawing of it is shown (as was shown for Exercise IV), but reference may be made to sketch in Fig. 27, as explained before. The student thus has opportunity to work out a practical problem from a sketch plan. The lettering and other details should be placed in their proper places, as on the previous exercises.

WALLS AND FOOTINGS

57. Foundation Walls.—Walls that are below the surface of the ground and support the superstructure, whether that superstructure is of wood, brick, or stone, are called **foundation walls.** They are sometimes built in trenches that are dug in the ground only sufficiently deep to reach below a level where frost cannot penetrate in winter, or occasionally they surround a cellar or sub-basement. In the latter case they must be made thick enough to withstand the earth bank that is piled against them.

Foundation walls are usually built of brick, stone, or concrete. Brick foundations are suitable only in very dry soil, and stone foundations are best when built of granite, sandstone, slate, or bluestone cushion. Other kinds of stone, however, will be found convenient in different sections of the country. Stone walls should be carefully laid with the joints well filled with mortar.

58. Brick Walls.—In laying brick walls, a bed of some sort is necessary between the bricks. Mortar of various kinds may be employed for this purpose, depending on the use to which the brickwork is to be put, and when this mortar bed hardens the wall consists of a homogeneous mass of bricks and mortar. In order, then, that the whole may consist of a solid mass of masonry, the brick should be properly *bonded;* that is to say, they must be so laid as to overlap one another in every direction. The mortar used for brickwork may consist simply of lime and sand, or cement and sand, or both, according to the conditions under which the wall is built. Lime mortar is used for all ordinary work, but for work below the surface, cement or hydraulic-lime mortar is necessary. The purpose of mortar in a brick wall is to keep out moisture by filling up all the crevices, to cement the whole fabric into one mass, and in setting, to form a cushion that will take up any unevenness of the brick and thereby distribute the pressure evenly. The thickness of the mortar joints depends largely on the character of the brick. Common rough brick require at least $\frac{3}{16}$ inch and never more than $\frac{3}{8}$ inch. Compressed brick are much smoother and can be laid with joints as small as $\frac{1}{8}$ inch, but $\frac{3}{16}$ inch insures better and stronger work.

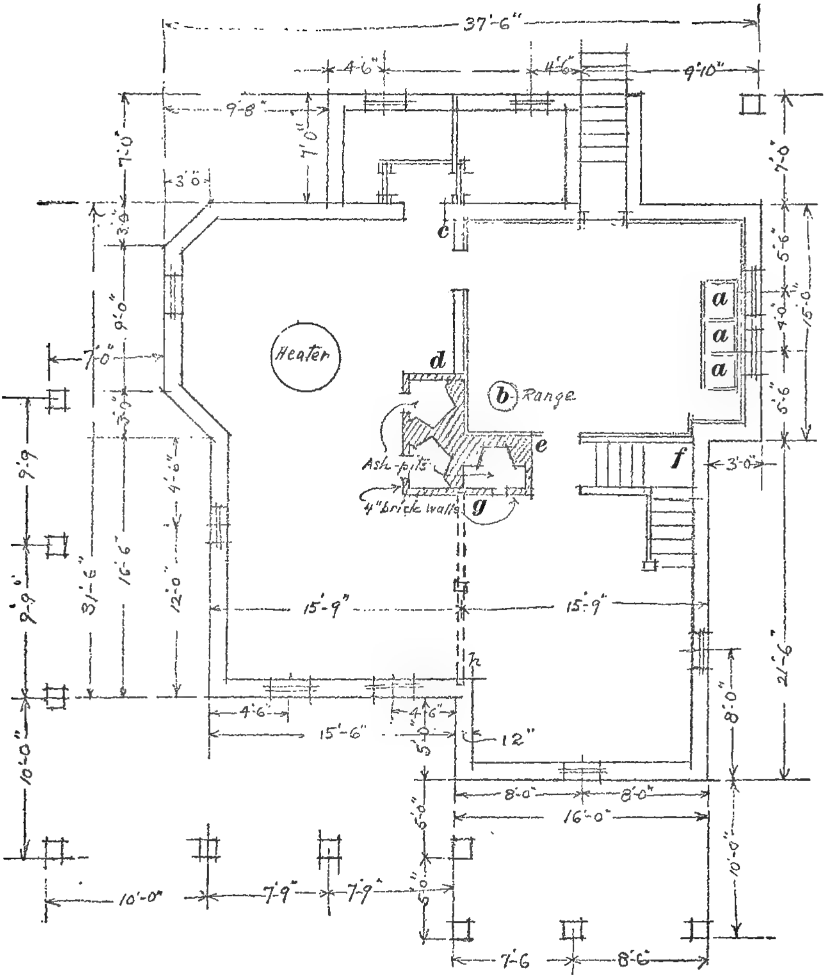
59. Footings.—Unless brick or stone walls rest directly on rock, a base, or **footing,** is laid under them. These footings, which may consist of concrete, stone, or brick, are wider than the wall itself, their purpose being to spread the weight over a larger area than the wall represents and to add stability to it. The width of the footings depends on the character of the soil on which they rest. Where built on rock, as already stated, no footings are necessary; on very hard soil, they are spread slightly; but on soft soil, where the wall is liable to sink considerably, the footings are made wide so as to distribute the weight over as large an area as possible. Concrete consisting of broken stones and cement makes a satisfactory footing in most cases, as it makes a practically solid stone beam on becoming hard. When large stones are used for footings they are embedded in concrete so as to give them an even bearing. Where footings are made of brick, the bricks are usually laid up in several courses, each course projecting about 2 inches beyond the one above until the required width is attained. In any case, the footings must be sufficiently deep in the earth to be unaffected by frost in the coldest weather. If footings are not placed below the frost line, the ground will heave as it freezes and throw the building out of plumb, cracking its plaster and destroying the equilibrium of the doors and windows.

EXERCISE VI, TITLE: CELLAR PLAN

60. The cellar or foundation plan of the house is usually made on a piece of tracing paper or tracing cloth placed over the first-story plan when the latter is finished, the arrangement of the first story being considered of first importance and the details of the cellar usually arranged to suit the floor above.

In Fig. 33 is shown the cellar enclosed with a 12″ brick wall that also flanks the outside cellar stairs. The foundations of the chimney and fireplaces are of brick, and the piers under the veranda posts are 12″ square. Stone walls instead of brick could be used here, but would show about 18″ in thickness, as 18″ is about the smallest width that a substantial rough stone wall can be built. The choice between a stone and a brick wall for the foundation depends entirely on the locality, stone being considerably cheaper if it abounds in the neighborhood. It is also desirable sometimes to use stone for foundations, both on account of its cheapness and on account of ridding the lot of loose stone that would otherwise have to be carted away.

61. In drawing Exercise VI, locate the plan in precisely the same position as the first-story plan was located, and then outline the position of the chimney so as to have a foundation and an ash-pit under the fireplaces. A laundry with three tubs as shown at *a*, Fig. 33, is built under the kitchen; these tubs are each about 2′ 2″ × 2′, and the complete row measures about 6′ 6″ in length by 2′ in width. They are located on the outside of the room so as to be under the windows, but the opposite side would have been better on account of plumbing arrangements if light could have been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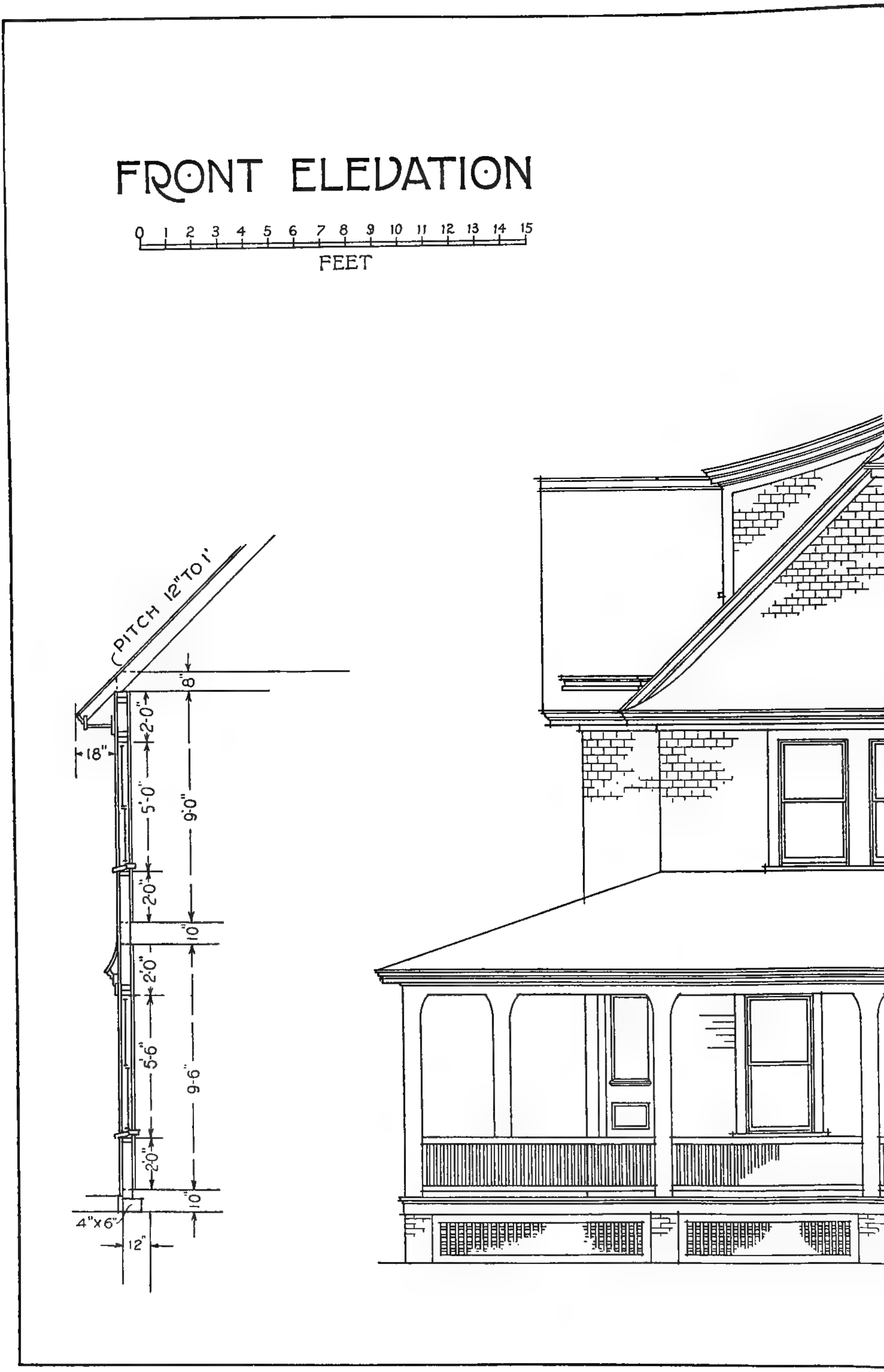
7'-6
8'-6"

Fig. 33

provided. As shown at *b*, a laundry stove about 2′ in diameter is provided in the opposite corner of the room. In order to finish the walls of the laundry, furring strips are placed on the stonework, and laths to receive the plaster are nailed to these strips; thus, within the room there is a line drawn 2″ from the stone wall to indicate the plaster line. The partition *c d* extends from the outer wall to the chimney foundation and contains a door 2′ 6″ that leads into the cellar proper, while the partition *e f* extends from the fireplace foundation to the outside wall and encloses a stairway. From *g* to *h* a 6″ × 8″ girder to support the floorbeams is placed under the hall and parlor, as, in framing, the beams would probably be laid across the house, one set of them resting on the partition *c d* and the other set on the girder *g h*. The furnace, about 4′ in diameter, is indicated in the main cellar. The space under the pantry is divided into two coal bins, and the windows are arranged so that coal may be supplied to either of the bins through them. The details of these windows were described and illustrated in Figs. 13 and 14, the former showing the frame built into a brick wall in the simplest possible manner and entirely different from other finished casings, and the latter showing a stone or brick wall surrounding the opening on three sides and a frame construction above. All the cellar windows are built in this manner and they differ only in the width, according to their positions. The steps leading from the laundry to the outside are built of flagstone, and the treads are about 10″ in width. They are enclosed between the foundation wall of the pantry and a brick retaining wall at their right, a section through these steps being shown in Exercise X, which follows later. This gives access to the laundry from the exterior, and the door at the bottom of the steps is paneled with glass so that a certain amount of light may be admitted when the door over the stairs is left open. Draw this plan to fit exactly under the first-story plan, and see that the general dimensions agree exactly with the first-story dimensions.

The foundation of the building rests on footings that are from 4″ to 8″ wider than the foundation walls, and consist



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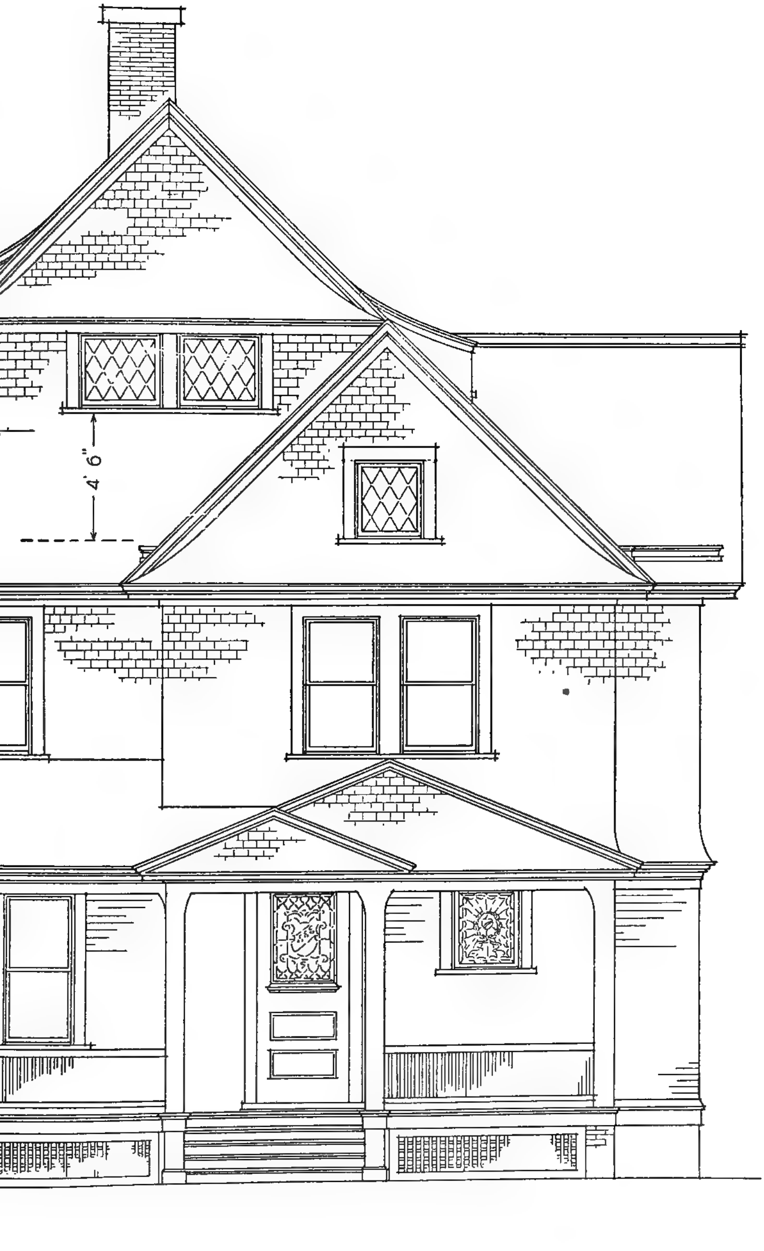


in
sheet

Name of Student, Class Letters and Number

of a trench filled with concrete or with large flat stones from 4″ to 8″ thick, according to the size and character of the walls to be supported. The footings are not shown in the foundations unless they are level with the cellar floor, which is seldom the case.

Execute this exercise according to the foregoing instructions. Color the foundation walls with Indian red to represent brick, and indicate the woodwork with burnt sienna, as before. Place the title as usual, and insert the name, class letters and number, the date, and the number of hours required to do the work in their proper places.

EXERCISE VII, TITLE: FRONT ELEVATION

62. Having finished the first-story, second-story, and cellar plans, the elevations will now be considered. The plans are usually worked out entirely before the elevations are commenced, and care should be taken that all the desirable arrangements are complete before any attempt is made at outside detailing. An illustration in the text is furnished with this exercise in order to show to what extent the front elevation may be finished, but this should not be used as a copy. The plans themselves are the only guide, and with these plans in mind the work of drawing the front elevation should be proceeded with, but to fit the plans the drawing that is given for an example is not to be copied.

63. Exercise VII.—This sheet will be laid out the same size as the previous plans, 14 in. × 18 in., with border line 13 in. × 17 in. Draw the ground line *a b*, Fig. 34, 1″ above the lower border, and thus represent the grade line of the lot, which in this case is practically level. Now, on the left edge of the drawing sheet and 1″ within the left border line, a section should be drawn representing the front wall of the house on a line through the windows. This sectional drawing will show a 6″ exterior wall with the window openings, the position of the floorbeams, and the slope of the rafters. It will also show the position of the veranda floorbeams and

the water-table, so that these details can be regularly projected into the front elevation when required.

64. The details of eave construction and the gutters for carrying off the water have already been studied in Exercise II, while the general character of the window construction has been taken up in Exercise III. The foundation walls under this building are of brick 2½″ thick, and on these is laid a 4″ × 6″ sill. The studs rest on the sill, and the floorbeams are notched over it and are spiked to both the sill and the studs, as all are placed each 16″ on centers. The outside sheathing is carried down over the sill, and the water-table is formed by nailing a 1″ × 3″ board at an angle of 45°. Under the water-table, an apron covers the sheathing and extends down about 1″ to 1½″ over the upper course of stonework, and the siding, or clapboarding, is commenced immediately over the water-table, the lower course of the clapboarding being beveled to fit the incline of the water-table. Now, the section at the left of the drawing sheet consists practically of a small-scaled diagram of the sill and water-table, as shown in Fig. 35, and a detail of the roof, as shown in Exercise II, while the openings of the windows are simply indicated in the studding, and the other details will be carried out in the elevation according to methods

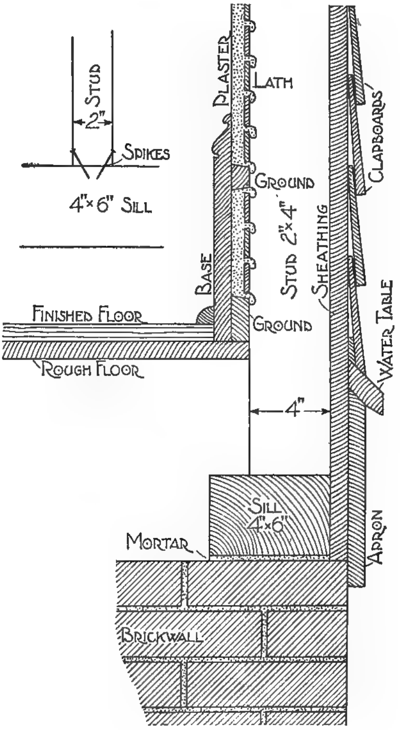
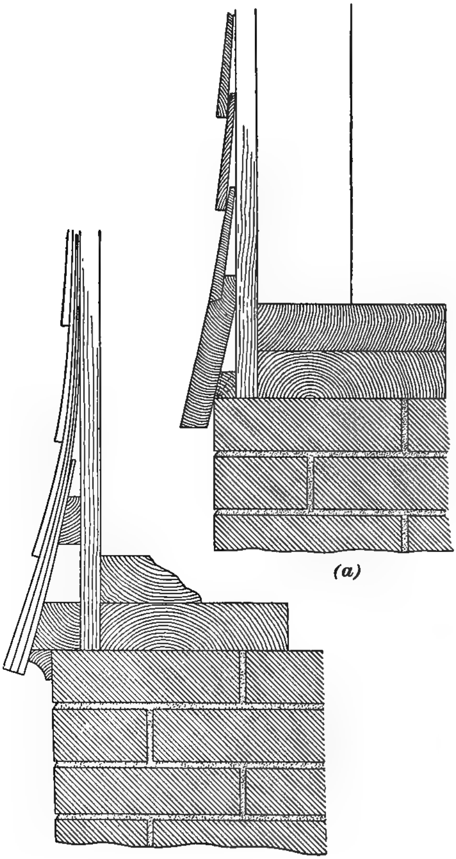


Fig. 35

given in Exercise III. Other methods of forming a water-table are shown in Fig. 36 (*a*), where clapboards are used, and at (*b*), where shingles are used. After drawing the section at the end of the sheet, the line *c d*, Fig. 34, representing the bottom of the water-table, should be drawn, which in this case happens to be in line with the veranda floor. Then draw the veranda cornice line *e f* at the same level as the top of the first-story window opening, and the line *g h* at the main roof according to the position determined by the projection of the rafter in the small sectional drawing to the left. Now, with a strip of paper about ½″ or ¾″ wide and 14″ or 16″ long, mark off the measurements from the plan so as to get the projection of the extensions on each side of the body of the house accurately, and the width of the hall extension and the projection of the veranda. This measuring strip can then be laid across the sheet that is to contain the elevation and will thus establish the points through which the vertical wall lines may be drawn. The main roof projects 18″ beyond the


(*a*)

(*b*)

FIG. 36

house line, and this distance should be marked off each side of the wall lines on the line *g h*. With a 45° triangle, the main lines of the gables should be drawn from *m* and *k*, while the left slope of the smaller gable is drawn from *l*. The house line *n o* of the veranda roof is placed at the under side of the second-story sills. The point *e* of the veranda roof is 11′ 0″ from the house line, as the veranda roof projects 12″ beyond the veranda floor and the floor is already known to be 10′ 0″ wide. Draw *e n*, thus giving a pitch to the veranda roof, and the slopes of the gables over the front porch at *r t s* are the same as that of the roof.

It is advantageous that any roof should have as much slope as possible, as it will shed water more readily and is less liable to leak. Therefore, when the eaves of the veranda are established as low as they can be conveniently put (which, in this case, is the top of the first-story windows), and the house line of the roof is placed as high as it conveniently can (which, in this case, is the bottom of the second-story sills), the greatest pitch that can be given to the veranda roof is obtained, and any pitch less than this can be easily arranged; but a greater pitch cannot be arranged without altering the windows. The point *p*, where the veranda roof intersects the hall extension, is lower than the other house line of the roof *n o*, and its exact location can be determined from the side elevation when that is given attention, but the side elevation has not yet been drawn, and it is desirable that this point should be determined at once. Therefore, in order to do this, bear in mind that the hall extension projects 5′ beyond the house line and that the slant of the roof will strike this extension 5′ in front of the house line. If, then, from the main line of the house 5′ is laid off as shown at *x*, and a perpendicular is dropped to the line of the roof pitch *e n*, a point where the roof will intersect 5′ in front of the house line will be established, and this point projected across to *p* establishes the roof line *p q* on the extension.

The eaves of the veranda gable are 12″ beyond the floor lines below, and slope to the ridge *t* parallel with the pitch *en*, the point *t* being exactly in the center of the hall extension. The line *ts* may be drawn the same as the other slope. The intersection of the slope *rt* with the house line *pq* establishes the point *q* at the end of the valley, as shown at *x*. The center line of the veranda posts should now be taken from the plan with the measuring strip and drawn with the elevation, as shown. The height of the gables *gu* and *hv* can be found in the same manner as the veranda roof line *pq* was determined. From the plan, it will be seen that the dining-room and kitchen extensions are each 3′ wide, and as the roof extends 18″ beyond each side wall, the height of the gable will be just one-half its width and *gu* and *hv* will each be 9′.

The window openings should now be located and drawn in. The mullion windows in the second story are each located in the center of the extension wall in which they are placed, and if not so situated on the plan, the plan should be changed to agree with the elevation that is being drawn. The windows were arranged in the plan without any fixed rules, but as it seems advisable to place the windows in the center of the walls, it may be necessary to change the plan to get the best results. Moreover, the final exercises in this Section will consist of a set of tracings taken from these plans, and if the plans and elevations of the tracings do not agree with the original elevation and plan, it will be necessary to go back over this work and make corrections. The windows in the parlor are so placed as to divide the wall approximately into equal parts, and the window in the hall is in the middle of its wall space on the interior. The door to the dining room from the veranda is at an angle of 45°. To draw this correctly, a small plan should be laid out as shown in Fig. 37, but the invisible line of the door projects in its proper place in the elevation.

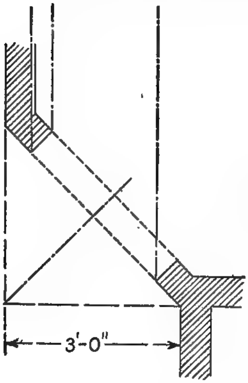


FIG. 37

65. The drawing plate should now present an appearance somewhat similar to that shown in Fig. 38, and as the general details are all located, the drawing can now be finished. The moldings of the main roof should be drawn from *g* to *h*, observing that these details are the same as those shown in Exercise II, and should return along the main gable lines *m y k*, and also along *l* to *z*. Note that the two outside lines run through from *y* to *k*, and that the other members of the molding miter under the smaller gable point and also finish against it from above. The windows in the attic are limited by the slope *l z*. Make the height of the openings level with the point of the gable *z*. Draw *z w* and locate the outside edge of the casing 1′ from the intersection of the outside of the sill and the roof line *l z*. Make this outside casing 5″ wide, and the mullion between 6″ wide. The shingling of the triangle over the gable will now be

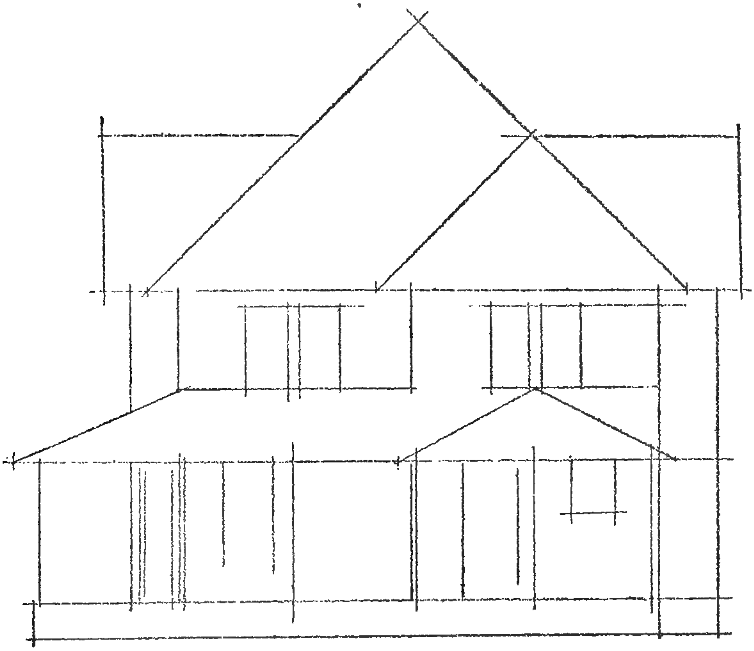


FIG. 38

splayed so as to project and form a window head—to *splay* means to round out, as illustrated in Fig. 39, which is a section through the small upper gable. In this figure is shown a blocking piece sawed to the curve of the splay, and spiked securely in front of each stud, and, as an additional thickness, sheathing is nailed to the block and bent to its curve. The shingling laid on the sheathing also conforms to this curve and makes a projecting soffit over the windows, as shown. This projecting soffit casts a shadow and breaks the monotony of the broad surface.

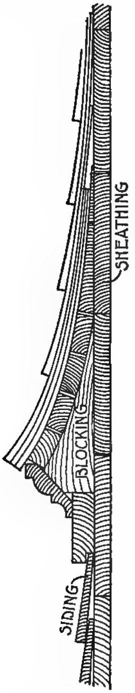


Fig. 39

The moldings at the sides of the gable *l* and *z*, Fig. 34, are intersected by this splay, and only the extreme outside members pass down to the eaves. A similar splay is effected across the lower portion of both gables from *m* and *l* to *k*, as indicated by the treatment of the moldings at these points of the roof slopes. Detail the attic windows as directed for drawing Exercise III, Sheet II, Fig. 4 *b*; show but one sash, as these windows will be hinged to swing open like a door. Draw all the windows of the second story according to the directions given in Exercise III, and after learning the size of the glass required, proceed with the other details accordingly. The moldings of the eaves *e s* and the gables of the veranda may now be drawn, carrying the lower members out to the string-course *f*. This string-course is carried out all along the house, and the details will be considered with a study of the side elevation. The veranda posts are 8″ square and are easily formed, as shown in Fig. 40. The railing is 2′ 4″ above the floor, thus making the top on a level with the bottom of the windows, while the veranda floor is 4″ below the house floor and pitches 2″ in its width, so as to drain to the outside. Therefore, its outside edge is 6″ below the house floor and 2′ 6″ below the bottom of the windows. The glass of the door and the hall window may be leaded in simple patterns. These should be sketched in as shown in Exercise VII. Vestibule and outside doors are shown on a larger scale in Figs. 58 and 59. Under each veranda post is a pier 12″ wide, and latticework is framed between the piers, as shown.

This completes practically all this elevation except the chimney and dormer-window. The chimney contains six

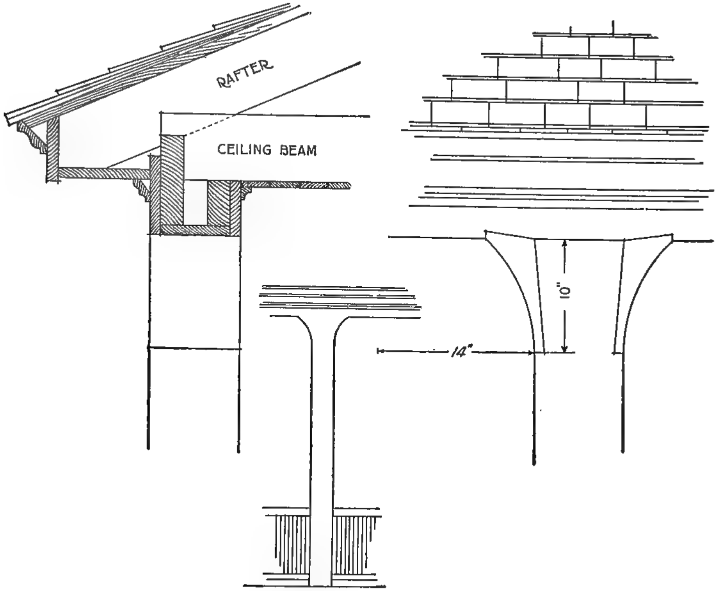


Fig. 40

flues, as was determined in drawing the second-story plan, and therefore must be at least 2′ 4″ wide and 3′ 4″ long. As it pierces the roof at the highest point, it need not extend much above the ridge, and on this elevation it will show 2′ 4″ wide and 3′ 4″ above the point of the gable. If the chimney came through the roof at a lower point, it would have to be extended above the ridge or it would not draw well. The dormer-window can be studied in the side elevation, so for the present simply draw the general outline of the sill 3′ above the floor. The eaves of the dormer-window roof are located about 5′ 8″ above the sill. The curve of the roof slant can now be completed freehand.

When this plate is complete, the title should be neatly lettered as shown, and the date, class letters and number, and time required placed as on previous exercise sheets.

EXERCISE VIII, TITLE: FIRST SIDE ELEVATION

66. The problem including Exercise VIII involves no detail other than that already determined for the front elevation, but after drawing the ground line *a b*, Fig. 41, $1\frac{1}{2}''$ above the lower border line, draw, as before, at the left and 1″ within the border line, a section through the structure showing the positions of the floors, etc. The section in this case is precisely like the section in the front elevation, except that the eaves and the pitch of the small gable are shown combined with the vertical studding that extends to form the wall under the main gable. There will be no printed drawing to work from in this exercise and ideas must be obtained from the preliminary sketch shown in Fig. 41. First, draw the water-table and the veranda level *c d* to correspond with this same detail in the front elevation. Then, do likewise with the string-course and veranda roof line *e m*, the main roof line *g h*, and the main ridge *j k*. The height *h l* is obtained from the gable over the hall extension in the front elevation, as is also *m n*, which is the height of the roof over the porch in the front elevation. The drawing of the veranda posts and the detailing of the first- and second-story windows are the same as in the front elevation. The dormer-window in the attic, however, will require more detailed description. It will be remembered that when drawing the front elevation this dormer was sketched in place rather roughly, and little attention was at that time given to the main detailing. The top of the sill is 3′ above the floor, and the windows are 3′ 6″ high. If each window is made 28″ wide with a 6″ mullion between them, and 12″ is allowed for the thickness of the wall and the trim on the inside, the

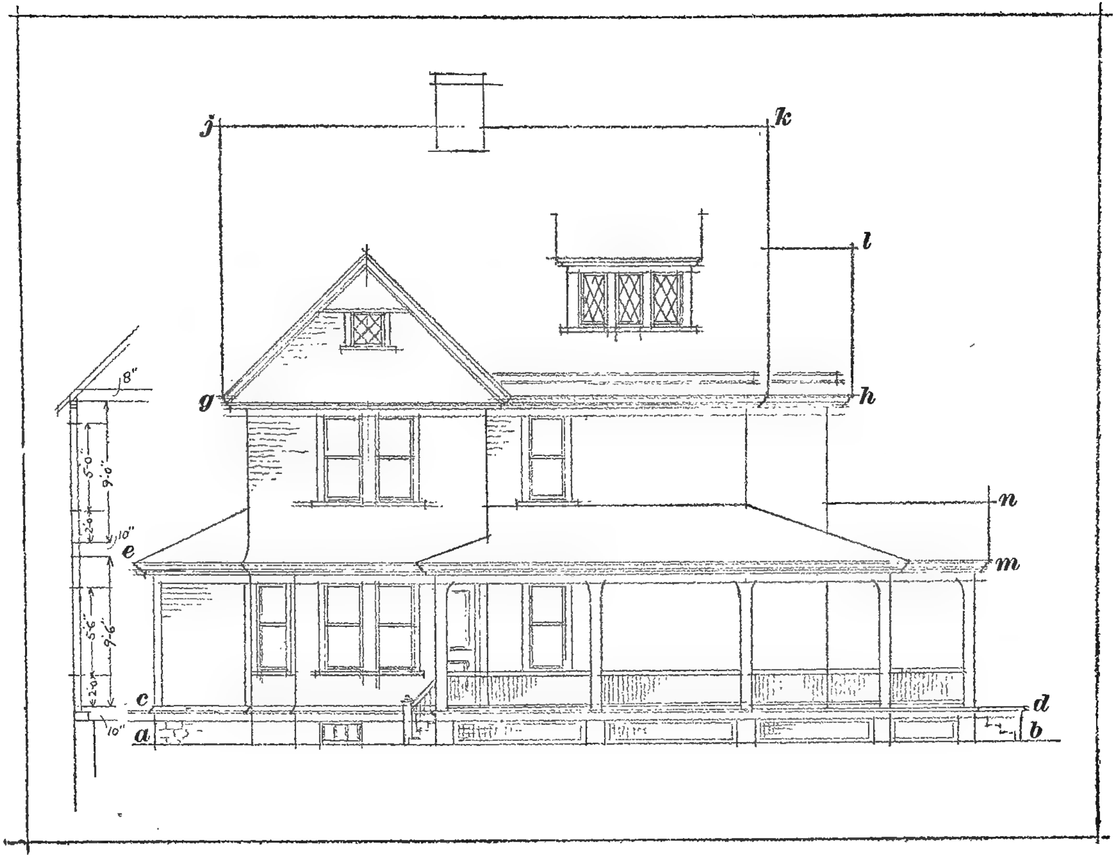


FIG. 41

total width for the dormer-window will be 10′ 0″. The three sashes in this dormer are hinged like those in the front dormer, and therefore no middle sash part is required. The roof should project about 10″ each side and then be carried back flat, but should be pitched as shown for the front elevation. The introduction of this dormer serves the purpose of breaking the monotony of the flat roof expanse between the end of the gable and the front of the house, and it also forms a pleasing detail in the small attic room that is finished off in the third story. The location of the other windows is determined very largely in the plan, as is also the chimney. The small extension at the rear containing the butler's pantry is roofed in the same manner as the veranda, but without so much projection. Where the veranda roof breaks around the dining-room bay-window projection, it presents a problem of the intersection of a plane with a prism, and is solved in precisely the same manner.

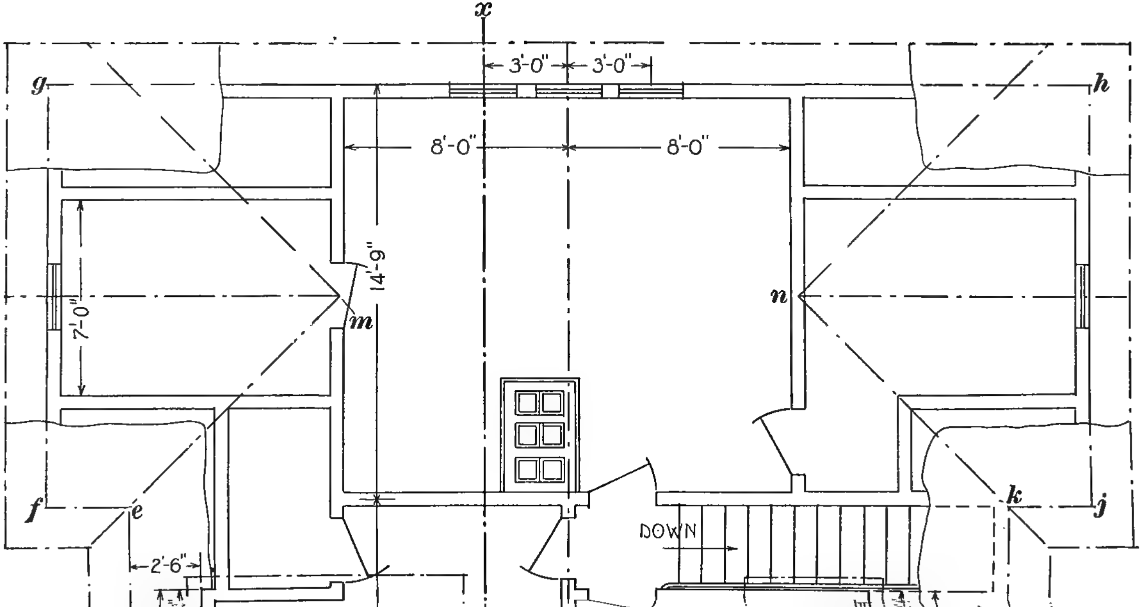
This exercise should be finished up, lettered, etc. in the usual manner.

EXERCISE IX, TITLE: ATTIC AND ROOF PLAN

67. Although the attic is usually considered the least important part of the house, it introduces occasionally, on account of its situation immediately under the roof, some very interesting problems when conditions of light and ventilation must be coped with. Up to the present time, the first- and second-story plans, two elevations, and a cellar plan have been completed, and the general appearance of the entire house should now be known. Therefore, in laying out the attic the details must conform to the conditions that already exist in the roof construction, or the roof must be varied to suit any more desirable conditions than can be worked out in plan.

In the same position as that in which the first-story plan was located on the drawing sheet, draw the dotted outline *a b c d e*, etc., Fig. 42, representing the portion of the main structure that is to be covered by the main roof. Then, turn

EXERCISE IX



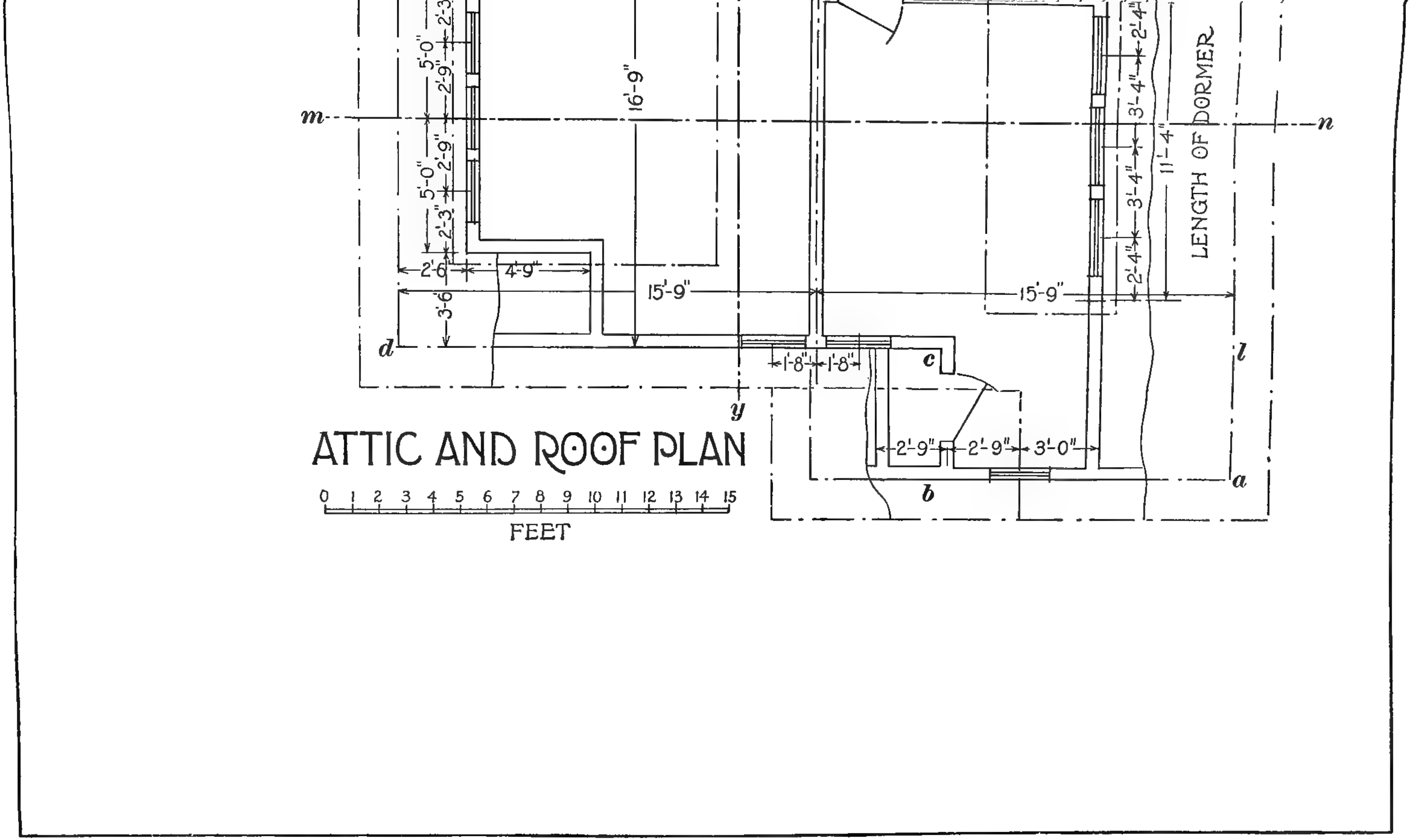


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FIG. 42

to the front elevation and find at what point above the attic floor headroom of about 6′ 6″ can be obtained. This applies to all attic rooms with the exception of the front room on the right. The front and rear gables of the house form the front and rear walls of the attic rooms, but the side walls will be entirely within the slope of the roof except where they are raised above this slope by means of dormer-windows.

The first problem to take into consideration is the stairway, and it is found that with fourteen risers the attic can be reached at a point about 6′ 6″ from the inside wall. The partition across the center of the house—against which the stairway runs from the cellar upwards—may be continued through the attic. To the right of the stairs in ascending is located a room 14′ 0″ × 16′ 0″ inside measurement, while at the end and to the left of the stairs are two rooms of smaller size, but large enough for attic bedrooms. The large room just referred to could easily be converted into two smaller rooms by extending another partition through the center from the chimney and omitting the central window at the end wall. The main hall would then have to be extended beyond the chimney sufficiently to get an entrance door into this second room. The dormer-window as drawn in side elevation is here contemplated in plan. It is 10′ 0″ wide and 3′ 6″ from the front wall of the house, and its face sets 2′ 6″ within the side wall of the house; it adds 4′ 9″ to the width of the room in which it is situated, and at the same time the three windows present an opportunity for a very pleasing interior effect. A closet is provided under the slope of the attic roof, as well as in each of the other rooms on this floor.

The roof of the main structure projects 18″ beyond the house line and is carried around the dotted outline, as shown. The main gable extends from *l* to *d* in front and from *h* to *g* in the rear, and the ridge extends through the center of the house, as shown by the broken line. The side gables that extend across from *f* to *g* and *h* to *j* intersect with the main roof and produce the valleys shown at *e m*, *k n*, etc. A broken line is carried around the attic plan to show the slope of the roof beyond the attic walls.

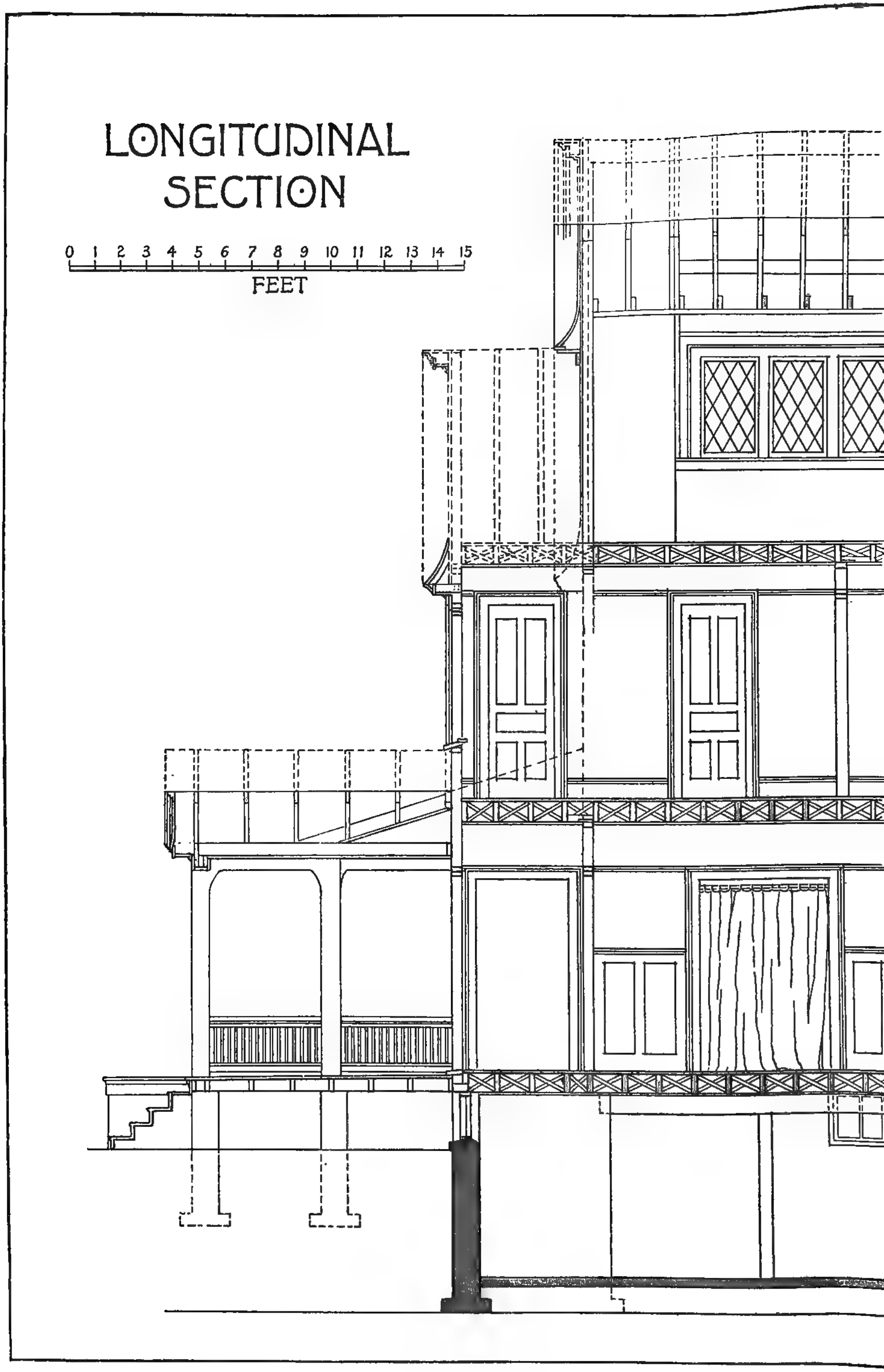
This plan should be worked out carefully from the other drawings, comparing the details of the plan with the front and side elevations and checking all measurements so as to insure the proper arrangement of the parts. Show the dotted outline of the building proper beneath the roof construction, and indicate the roof ridges and valleys with a dashed-and-dotted line as shown. Place the title on the drawing as shown in Fig. 42, also the name, class letters and number, date, and time consumed in their usual places, completing the drawing in every detail. Sections of materials must be properly colored, as on former exercises.

EXERCISE X, TITLE: LONGITUDINAL SECTION

68. One of the most important details in the set of plans for a house is the longitudinal section, as it gives information in regard to many details of the interior that cannot be learned from the plan. This section shows methods of construction that do not appear elsewhere, except by description in the specifications, and, therefore, in drawing a section, the utmost care should be taken to have it conform with that description.

On looking at this longitudinal section, Exercise X, it will be observed that all the doors shown contain five panels, and that the first-story hall is wainscoted to a certain height, as is also the kitchen and the bathroom. These details must agree with the specifications, otherwise disputes may arise when the contractor endeavors to carry out his work.

A section consists of an interior elevation of the entire construction, and presents the house as it would appear with one portion sliced off or removed. This division need not be made in any particular place, but is usually so chosen as to show the interior details to advantage. The line of the section is generally indicated on the plan, as shown at *x y*, Exercise IV. This line need not be in the same place in each story, and in this case it is taken in the first story so as



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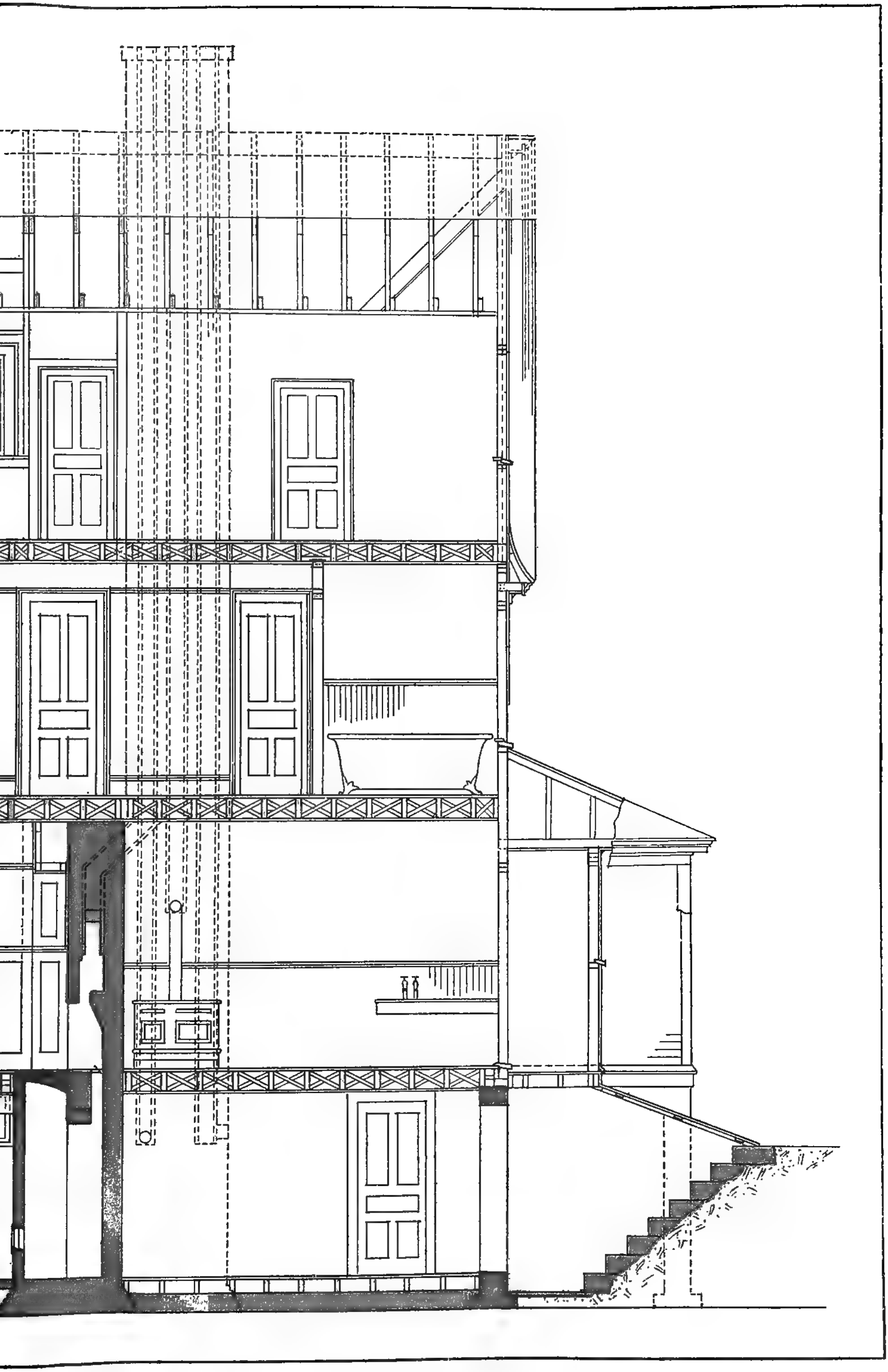

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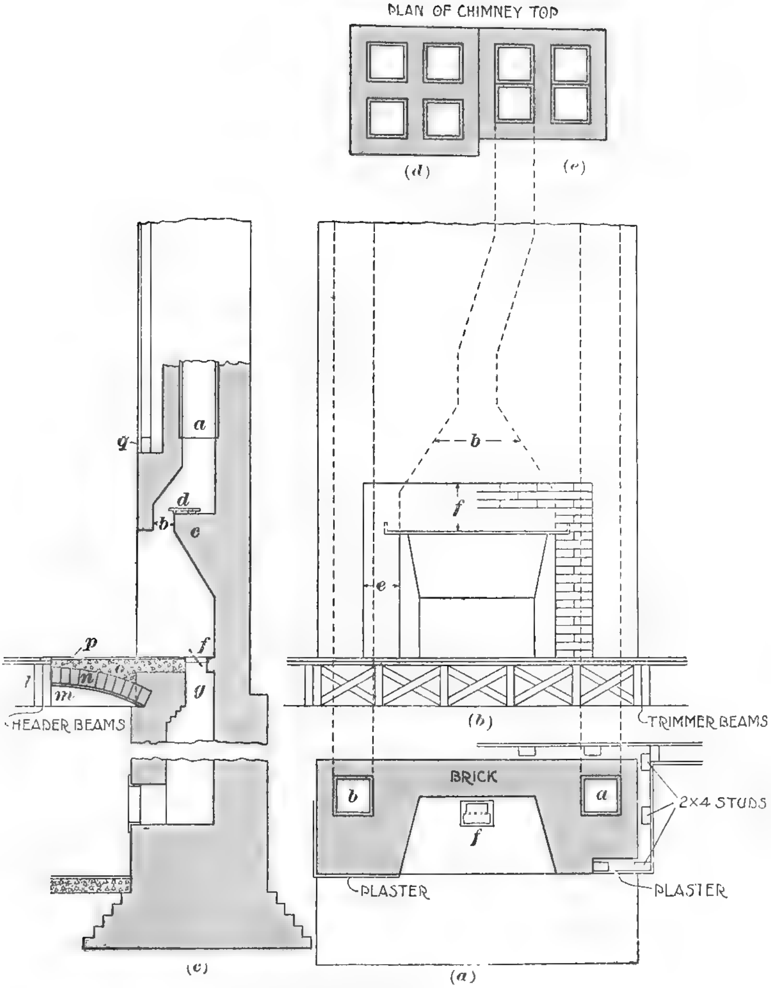

PLAN OF CHIMNEY TOP
(d)
(e)
a
g
d
b
c
p
f
l
n
o
m
g
HEADER BEAMS
(c)
b
f
e
(b)
TRIMMER BEAMS
BRICK
b
a
f
2×4 STUDS
PLASTER
PLASTER
(a)

Fig. 43

to show the elevation of the hall, a section through the fireplace, the side wall of the kitchen, and the section through the outside cellar steps, while in the second story it is taken to show the elevation of the front room and bathroom, and at the same time, by dotted lines, illustrates the arrangement of the flues and the carrying of the chimney up through the roof.

69. Chimneys.—In laying out the plans for fireplaces and chimneys, the principal points to be considered are the height of the chimney and the number of flues, as every fireplace must have a separate flue extending through the roof. Two or three small stoves, when used, may occasionally be connected up to one flue, if the flue is of sufficient size, and the kitchen range connected with the furnace flue often assists the draft, but the area of the flue must be sufficient to carry the smoke from all the heating devices vented into it. An ordinary stove or a small furnace requires an 8″ × 8″ flue, which should be plastered smooth on the inside, but an 8″ × 12″ flue is better for a furnace, unless small, and for all fireplaces except those using very small grates. The sectional area of the flue should usually be about one-twelfth to one-tenth that of the fireplace opening. Fireplaces are usually from 2′ 6″ to 4′ 0″ wide, 16″ to 24″ deep, and about 2′ 6″ high. When higher than this, it is usual to provide sliding aprons of metal to reduce the height of the opening until the fire is well started. Generally speaking, a flue built of brick and lined with fireclay or tile is best, or in some cases a galvanized-iron pipe lining will suit the purpose admirably, although it is liable to rust out in a short time.

A chimney should always extend above the highest point of the building, otherwise the flues will not draw well and the house will always be filled with smoke when a fire is started and frequently when the wind is in an adverse direction. In building a chimney, a certain amount of plaster and other refuse is sure to fall down the flues, and for this reason there should be an opening at the bottom so as to remove this rubbish. Where bends or deviations occur in the flue, they should be gradual and not abrupt. Openings should also be left in the bends when building, so that pieces of brick and mortar that fall down the flue during construction may be removed from where they lodge in these bends. These openings can be bricked up after the chimney is completed. The thickness of the outer walls of the chimney should never be less than 8″, unless terra-cotta flue lining is used, and woodwork framed around the chimney should come no nearer the walls than 1″.

70. A fireplace is shown in Fig. 43, (*a*) being a plan view, (*b*) an elevation, and (*c*) a section. In the plan, flues are shown coming from the story below, and the dotted lines in the elevation show the direction of these flues as they are carried up to the roof. The dotted line in the elevation also shows the deviation of the flue in the fireplace *b* in order to carry it to its proper place at the outlet. The left half of the plan is shown with the plaster laid directly on the brickwork, while the right half shows the chimney partly surrounded by a lath-and-plaster partition. As will be observed, the studs are laid edgewise and 1″ away from the brickwork, thus making the space from the brickwork to the outside of the partition 4″; that is, 2″ for the thickness of the stud, 1″ for the thickness of the lath and plaster, and 1″ for the space between the stud and the brickwork. Two plans of the chimney top (*d*) and (*e*) illustrate the construction of brick partitions and terra-cotta flues. With the former, a thick outside wall and a 4″ partition between the flues is necessary, and the total area of the chimney is considerably more than where flue linings are used, as can be seen by comparing the left half of the plan with the right half.

71. Brick flues should have 8″ of brickwork all around the outside of the chimney and 4″ between the flues. The joints must be struck smooth, but the inside should never be plastered with mortar, as it is liable to crack off and fall into the flues and clog them. Terra-cotta flue linings require only 4″ of outside brickwork, and they can be set in groups of two or four with an occasional 4″ tie-wall between them, as shown in the right half of the plan (*e*). The saving of brick and economy of space make terra-cotta lined flues less costly in the long run than the plain brick construction. The first cost of the latter, however, is less, and in cheap constructions some owners will insist on using brick.

As shown at (*b*), the flue should extend to the center of the fireplace below in as direct a line as possible. The sides of the fireplace at the top are gradually brought together until reduced to the normal width of the flue directly over the center. Then, the flue may be deflected to one side or the other until it is in line with the chimney opening above. If the flue starts from one side of the fireplace, the draft will be greater from that side, and the opposite side will be liable to smoke.

The face around the opening should be of brick, tile, or metal, and the distance from the opening to the nearest woodwork of the mantel should never be less than 8″ at the sides *e* or 12″ at the top. Where a brick face is used, the bricks should be built up as a structural part of the fireplace and not simply laid on as facing.

72. In the section at (*c*), the terra-cotta lining is shown coming down to the top of the fireplace at *a*. The flue then decreases in depth at *b*, while in the elevation (*b*) it increases in width at *b*, as shown. This portion leading from the fireplace to the flue is called the *throat*. The back of the fireplace is brought forwards, as at *c*, and behind the throat a shelf is formed, on which slides a cast-iron damper *d* to vary the opening *b* and regulate the draft.

In the hearthstone is another opening *f*—seen also in the plan (*a*)—containing a pivoted door or trap over the ash flue *g*. Ashes on the hearth can thus be swept into the flue, and allowed to fall into the ash-pit in the cellar. The front of the ash-pit is closed by a cast-iron door through which the ashes may be removed from time to time. The hearth is supported on a *trimmer arch n*, which is formed of one course of brick laid over a curved wooden form *m*, called a *center*, and resting against a double floorbeam *l*, called the *trimmer*. The span over the arch and up to the level of the tops of the beams is filled with concrete *o*.

Above the fireplace opening, the chimney breast may be carried up straight to the fireplace on the floor above, if there is any, or it may set back so as to leave only a 4″ covering of brickwork over the flue lining and thus present a wider mantel shelf; or it may be set back as stated and furred out so as to show a flush finish, as at *q*.

73. Exercise X.—In drawing the longitudinal section, Exercise X, a horizontal line should be placed $\frac{1}{2}$″ above the lower border line. This will represent the lowest point of the excavation for the foundation of the building, and the brick walls representing the foundation should be drawn in place as shown. The ground, or surface, line is about 3′ below the floor of the house, and in order to get 7′ of headroom in the cellar, it is necessary to lay the foundation of the house 9′ 4″ below the top of the first floor. This enables the footings to be carried below the concrete floor of the basement.

The footings under the veranda posts need not extend so far, and are carried down to 3′ below the surface in order to avoid the effects of frost. In warm climates they need not be so deep, while in extremely cold localities they might well be deeper. The side walls of the house are built on wooden sills laid on the brick walls, as illustrated in Fig. 35. A layer of mortar is spread on top of the brick wall and the wooden sill is laid in it and pounded into place until the top is level. The 2″ × 4″ studs are then placed on the sill and spiked at the foot as shown in Fig. 35. The sheathing is then secured to the outside of the studs and the clapboards are nailed over the sheathing. On the inside, the studs are lathed and plastered with $\frac{7}{8}$″ grounds placed at convenient intervals to nail the inside trim and base.

Two thicknesses of flooring are usually laid over the beams; one is made of rough boards $\frac{7}{8}$″ thick, which are laid diagonally, and serves as the working floor while the plastering and other rough work is being done, and the other is a finished floor of fine-surfaced boards $\frac{7}{8}''$ thick, which is afterwards polished or painted to match the interior finish of the house. Some buildings are completed with only a single floor, but this is poor practice, for dust readily sifts through the cellar into the first story, and it is more difficult to keep the house warm in cold weather. Under the laundry, 2″ × 6″ beams are laid on top of the concrete, and a wooden floor is laid over these.

The wainscoting in the hall is more clearly shown in the details of Figs. 28 and 29, while that of the kitchen is detailed in Fig. 44 (*a*), and the bathroom is executed as shown in Fig. 44 (*b*).

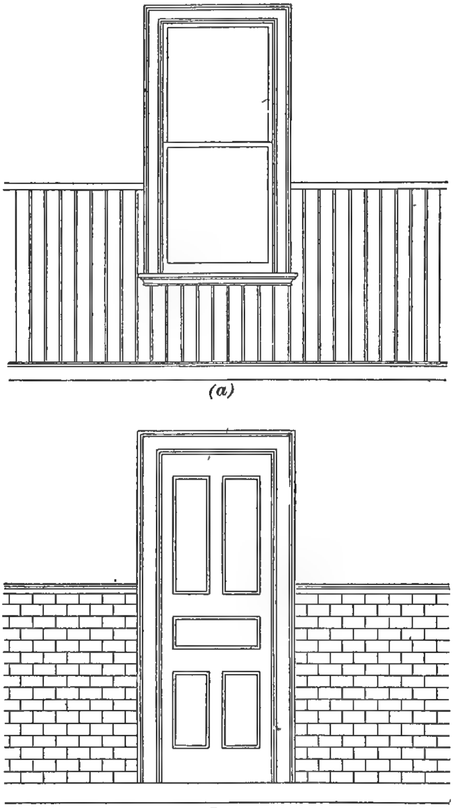


FIG. 44

74. The sill under the opening of the front door and kitchen door should be constructed as shown in Fig. 45. A piece of 2″ stuff *a* is secured to the inside of the studding parallel and level with the floorbeams *b*. This forms a nailing place for the ends of the rough floor boards *c*. On the outside of the studs a similar piece of stock *d* is secured to receive the ends of the porch floor boards *e*, which have an inclination of about $\frac{1}{4}''$ in 1′. After the rough inside floor and porch floor have been laid, the door sill *f*, 2″ in thickness, is laid inclining to within about 1″ of the porch floor. The inside finish floor fits against the sill and is tongued into it as shown. The width of the sill varies under different conditions; it may extend from the plaster line on the inside to the sheathing line on the outside, or even beyond the outside trim or casing as it does in this case.

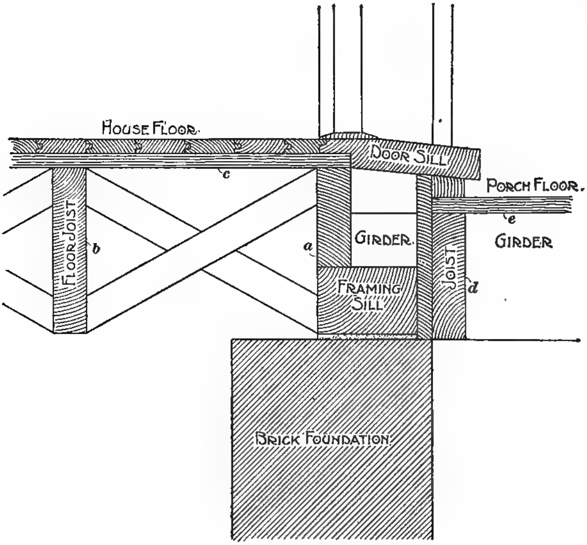


Fig. 45

When the floorbeams are at right angles with the wall, the inside construction is as in Fig. 35 and the outside as in Fig. 45.

The cellar windows under the porch are constructed as shown in Fig. 14, except that the floorbeams above run parallel with the wall instead of resting on it, and the details of these beams are the same as in Fig. 45.

The veranda floor pitches 2″ from the the door sill to the outer edge, and is detailed as shown in Fig. 46. From the brick foundation wall to each of the piers 6″ × 6″ girders extend, carrying 2″ × 6″ veranda joists spaced about 16″ on centers. The porch floor boards are then laid across these floorbeams perpendicular to the house line, so that the joints between the planks will not catch water and cause rot to set in.

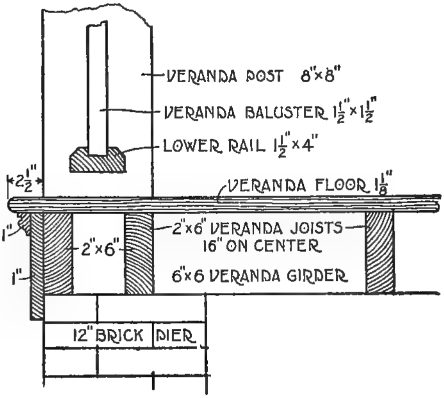


Fig. 46

75. Where partitions rest on and are parallel with the floorbeams, without other partitions below, they are detailed as shown in Fig. 47. Two 3″ × 10″ beams are placed under the floor where the partition is to rest. If the partition is to carry flues or pipes for heating the rooms above, the 3″ × 10″ beams are spaced about 6″ apart, so as to leave room for the pipe to pass clear of them without cutting; but if there are no pipes, as in the case of the vestibule partition in this section, the 3″ × 10″ beams may be put close together and the partition sill placed directly on them, leaving 1″ each side as a nailing space for the rough floor boards.

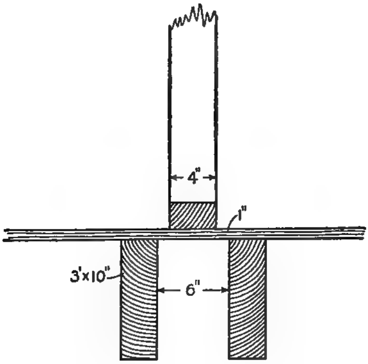


Fig. 47

Where a partition does not extend through to the floor above, it is usually finished against the ceiling, as shown in Fig. 48. Pieces of 2″ × 4″ studs are framed in between two floorbeams and nailed to the partition cap when the partition is in place. Between these pieces, sections of 1″ × 6″ board are nailed to the partition cap projecting 1″ each side so as to form nailing surface for the lath on the ceiling.

The outside cellar steps consist of bluestone blocks laid one over the other, as shown in Fig. 49, their outer ends resting on the brick retaining walls shown in the cellar plan.

76. The doors in the longitudinal section are 7′ 6″ high on the first story and 7′ 0″ high on the second story, and should be five paneled. The one from the laundry to the cellar is 6′ 6″ high. In Fig. 50 is shown a detail of one of these doors. The principal members consist of the *panels a*, the *rails*, or horizontal members, *b*, and the *stiles*, or vertical members, *c*. All doors consist of a combination of these members, except *batten doors*, such as are used over the outside cellar stairs, and *ledger doors*, which are used largely for barns and outhouses.

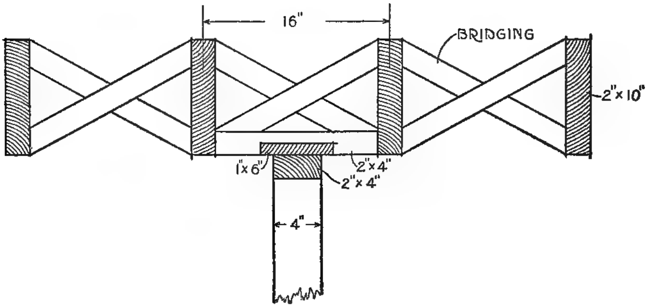


Fig. 48

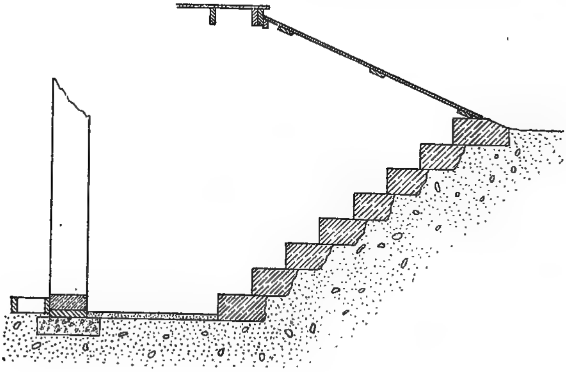


Fig. 49

In a paneled door, the lock should be so placed as to come opposite a panel, and not opposite the end of a rail. The rails are tenoned, or tongued, into the stiles, and cutting for a lock is liable to injure the joint. The door knob, or latch, should be placed about 2′ 9″ above the floor, so that this dimension approximately fixes the position of one of the horizontal panels, if there are any.

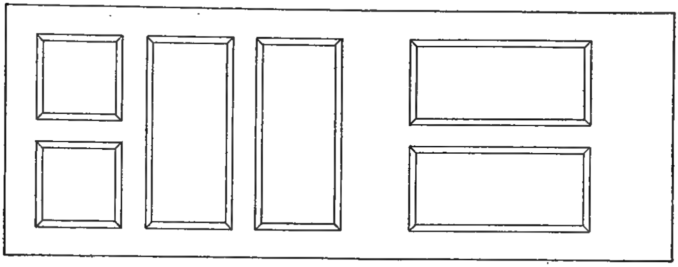


FIG. 52

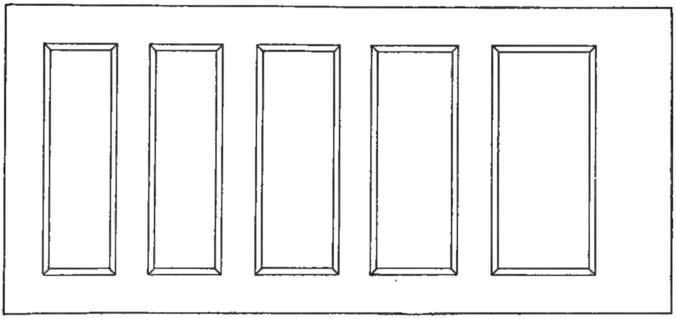


FIG. 51

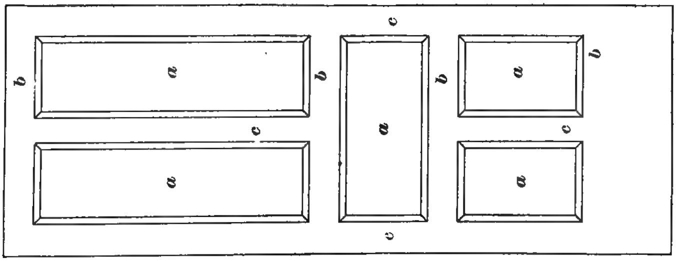


FIG. 50

The stiles and top rail of a door may be from 4″ to 6″ in width, while the bottom rail should not be less than 9″, and in large doors, may be as high as 12″, the middle rails varying from 4″ to 8″ in width. In Fig. 51 is shown a door with five horizontal panels, and in Fig. 52, a design with panels of three different sizes. Doors with one large, single panel are used largely in colonial work, as are also the forms shown in Figs. 50 and 51.

77. The thickness of doors varies according to their quality and purpose. For small doors, such as are used for kitchen and pantry dressers, the stiles are usually made from one piece, and the thickness seldom exceeds $1\frac{1}{8}''$ and is frequently as little as $\frac{3}{4}''$, as shown in Fig. 53. At (*a*) is shown a simple door $\frac{3}{4}''$ thick with a solid panel. The panel is held in a groove cut in the stile, or rail, as shown at *a*. The stile is molded on one side, and a bead on the panel makes the finish on the other. This is suitable for a dresser, or cupboard door that is to show on both sides. At (*b*) is shown a similar door, intended to be seen on one side only, while at (*c*) is a door having the stile molded on both sides and a plain panel inserted. At (*d*), (*e*), and (*f*) are shown similar stiles with glass panels.

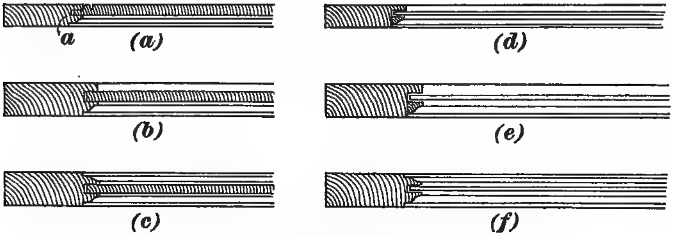


Fig. 53

For communicating doors placed between rooms, the stiles are usually made from $1\frac{1}{2}''$ to $1\frac{7}{8}''$ in thickness with solid or single-piece panels. In Fig. 54 are shown several forms of these doors. At (*a*) is a plain door similar to Fig. 53 (*c*), except that the stile is $1\frac{1}{2}''$ thick; (*b*) is also similar to Fig. 53 (*c*), but the panel is thicker in the center. A panel like this is called a *raised panel.* At (*c*) is shown the best form for one of these cheap doors. The panel moldings each side and the stile of the door are separate pieces. The panel can be removed and replaced without taking apart the entire door. Glass panels are shown at (*d*), (*e*), and (*f*).

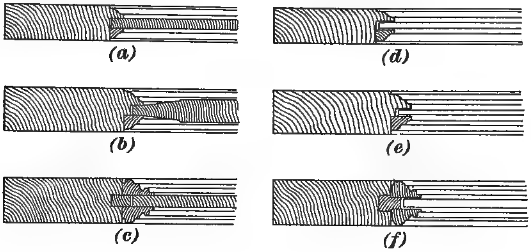


FIG. 54

For high-quality doors finished in hardwood, it is necessary to use veneer glued to a built-up core. A few forms of built-up cores are shown in Fig. 55. At (*a*) the core consists of five pieces of pine *a* glued together to form a solid plank. The end-piece *b* and the surface *c* are of oak, mahogany, or other hardwood, and the molding *d* and the panel *e* are solid. At (*b*), the treatment is similar, but the panel is veneered also, while at (*c*), the solid panel is again used with a different treatment of the details on opposite sides to suit the conditions of the two rooms. Glass-paneled doors are shown at (*d*) and (*e*), and (*f*) is a heavy-framed door suitable for a sliding door in a large opening.

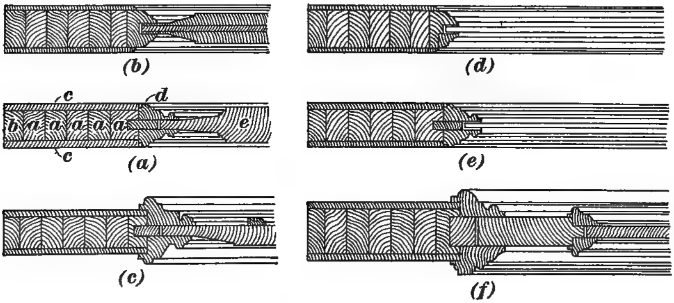


FIG. 55

78. Where sliding doors are used, the partition in which they slide must be framed especially for them. In Fig. 56 (*a*) is shown a plan, at (*b*) an elevation, and at (*c*) a section through a sliding-door partition. The studs *a* are spaced about 5″ apart in the clear, and are lined on the inside with ½″ boards to form a pocket in which the door slides. When 2″ × 4″ studs are used, the sliding-door partition is about 11″ in thickness, but when 3″ × 4″ studs are used, a better piece of work is accomplished and the partition is 13″ in thickness. At the door head, as shown in the section (*c*), sufficient space is left to permit hangers or rollers to be inserted. In Fig. 57 (*a*) is shown an enlarged detail of the pocket construction in plan; at (*b*), a section through the pocket and door head; and at (*c*), a section through the lower rail.

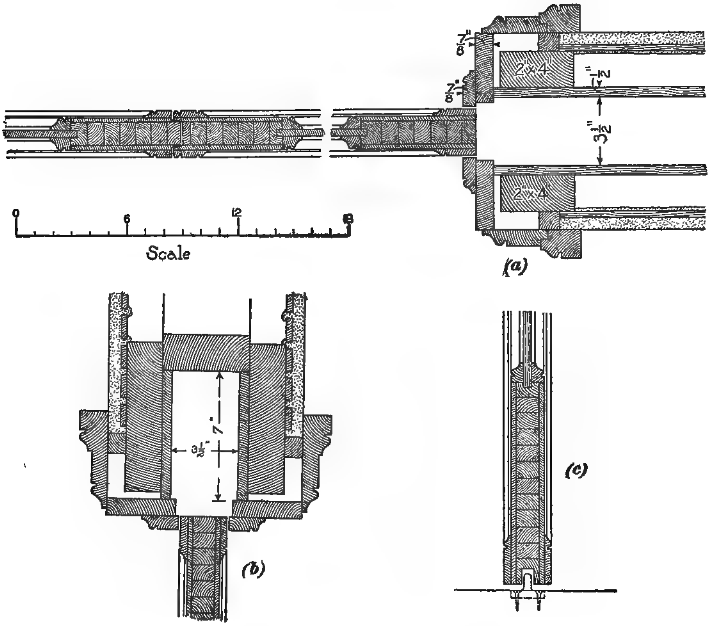


FIG. 57

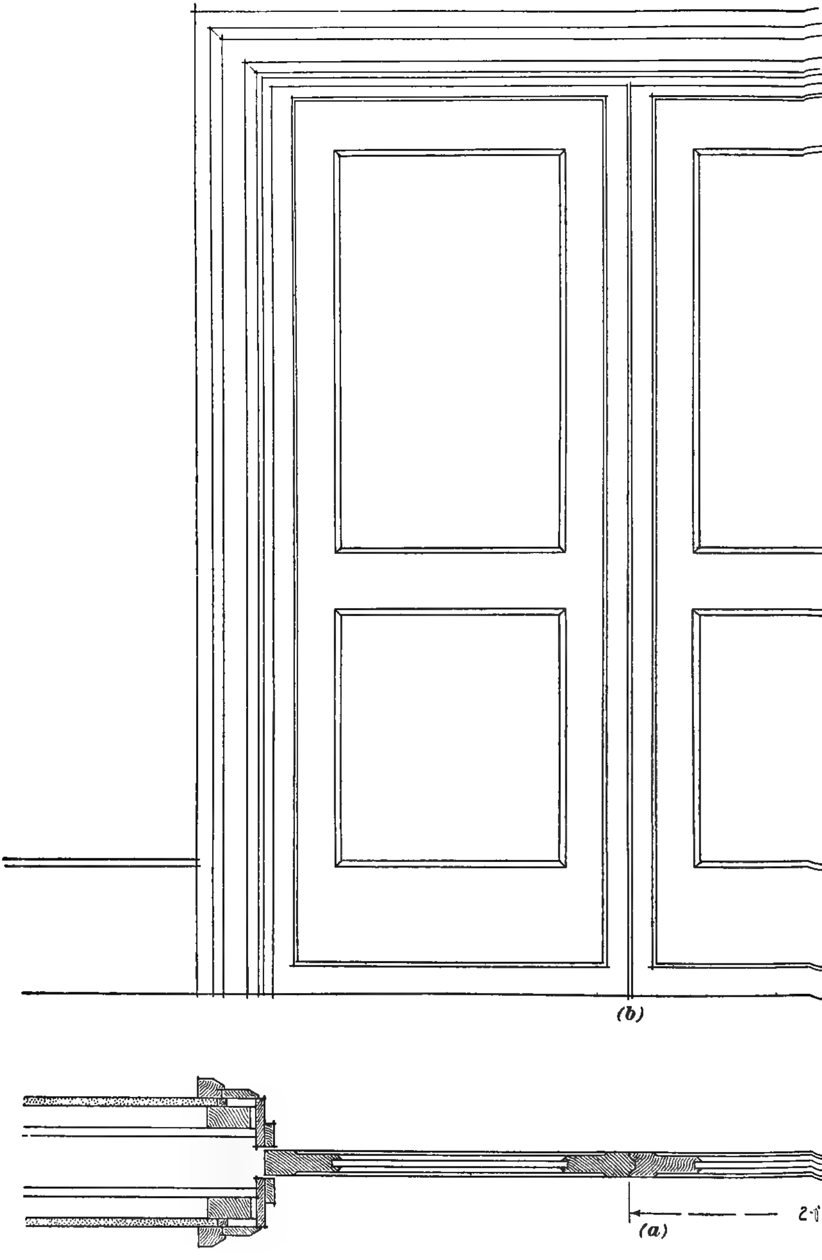
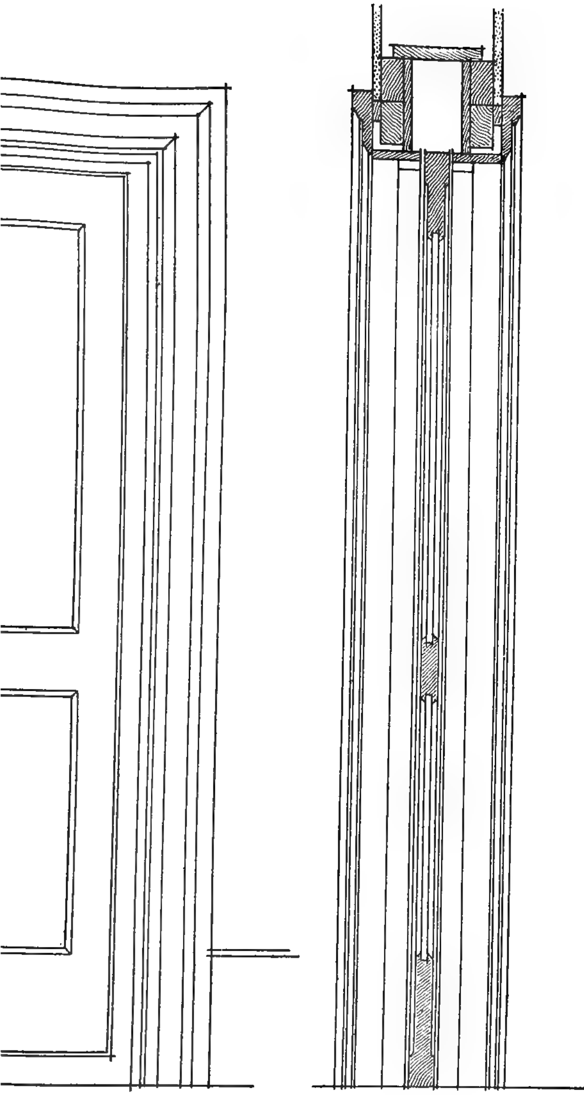
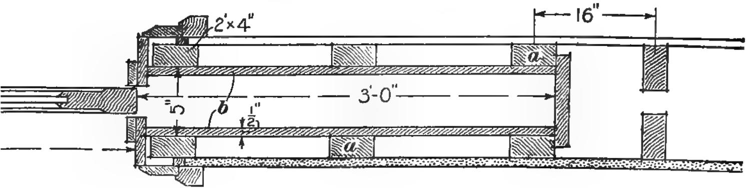


FIG. 56



(c)



Front, or vestibule, doors are made in different forms. The upper panel may be of plain or leaded glass, as in Figs. 58 and 59, or it may be solid or grilled, as in Fig. 60. The door shown in Fig. 58 is suitable for any style of modern country house. The upper and lower halves are made separate, so that the upper one may be open for ventilation while the lower one remains closed, the line between the two sections being shown at *a b*. Each section must have a separate lock, however. A door of this type is usually termed a *Dutch door*. The door shown in Fig. 60 is also a Dutch door, in construction as well as in design. The upper and lower sections are hinged separately and are parted on the line *a b*. The lower section is apparently composed of vertical strips of oak held together by double wedge-shaped pieces inlaid across the joints. Heavy strap-iron hinges

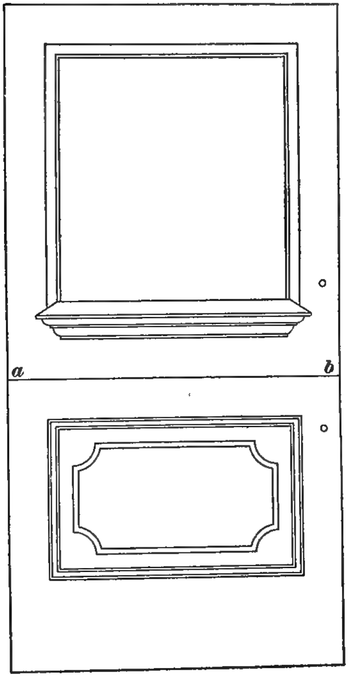


FIG. 58

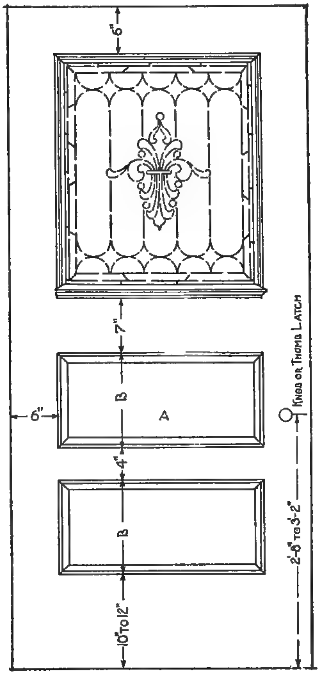


FIG. 59

extend across the boards and assist in securing them, and an iron lattice grille protects the glass.

The sizes of the doors are marked on the plan, but in making the drawings it is unwise to mark the size or to number the panels in the door until the section is finished, for there are many cases where this cannot be well determined beforehand. The purpose of the longitudinal section is to show construction.

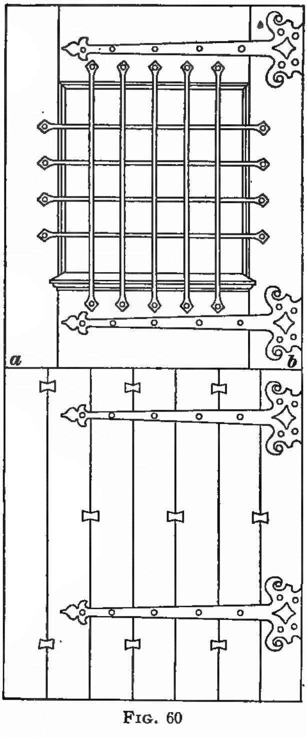
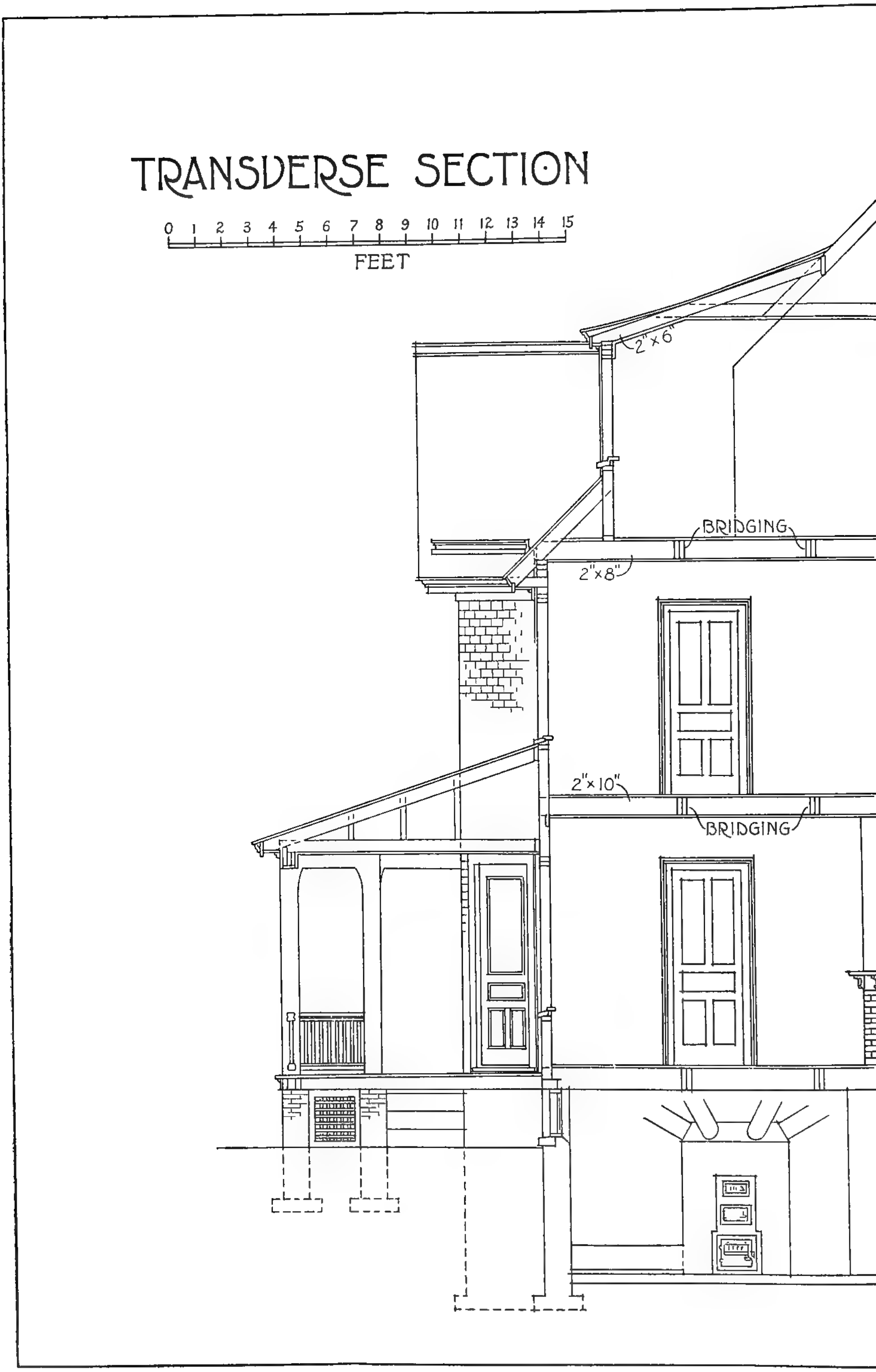


FIG. 60

79. The construction of the eaves and gutters is precisely as in Exercise II, and the section through the windows should be detailed as in Exercise III. In general practice, when only a $\frac{1}{4}''$ scale is used for drawing, it is not considered advisable to show all the details of lath-and-plaster construction through the section of a partition, and where the section passes through a doorway it is not usual to show the section of the door itself, although the construction of the doors is a matter of considerable importance.

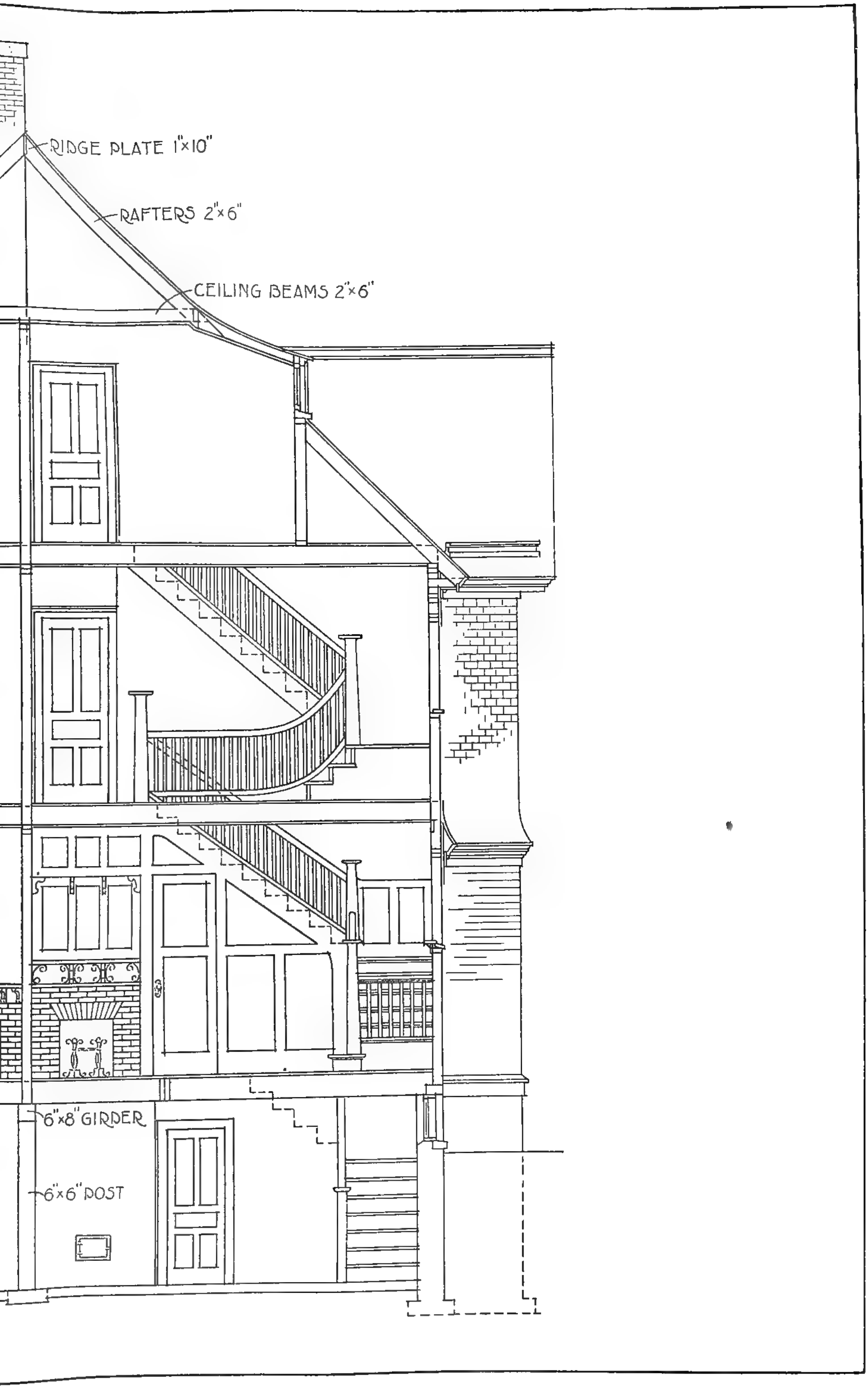
The beams in the top story are $2'' \times 8''$, spaced 16″ on centers, and between all these floorbeams is a series of braces made of $1\frac{1}{2}'' \times 2''$ stuff, called *bridging*, which serve to keep the beams from curling out of their places and thus rendering the floor uneven and cracking the plaster. The roof beams, as seen in the attic, are spaced 20″ on centers, and where it is necessary to frame in a dormer-window as shown, the arrangement of the rafters is not changed, but the window is framed in between the two most convenient ones and the space between is blocked out as shown in the longitudinal section.


TRANSVERSE SECTION
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
FEET
2"×6"
BRIDGING
2"×8"
2"×10"
BRIDGING

Date

Time

E XI



l in
sheet

Name of Student, Class Letters and Number

The rafters under the roof are 2″ × 8″, spaced 20″ on centers, the first one being placed immediately over the plate and the others spaced from it. The rafters nearest to the dormer-windows are doubled, as shown, and between them a sill and plate are framed to form the dormer. A ridge plate at the peak of the roof receives the upper ends of the rafters, as will be more clearly seen on the transverse section that follows. A long valley rafter extends from the foot of the side gable across to the end wall, as shown at *a b* in Exercise IX, and another valley rafter extends from the other foot of the side gable until it meets the rafter, as shown at *c d* in Exercise IX. This exercise should be finished up and lettered as were the former ones.

EXERCISE XI, TITLE: TRANSVERSE SECTION

80. Exercise XI represents the cross-section of the building on a line at right angles to that on which the longitudinal section was made, and shows on each floor the particular arrangements of the interior details. The section is not taken on the same line on each floor, but is varied in a general way so as to bring into prominence the various important constructions that it is necessary to illustrate. In this transverse section, the line in the cellar is taken to show the elevation of the stairs to the first floor, the door into the laundry, and the furnace room. In the first, second, and third stories, the section shows a general arrangement of the stair system and the end elevation of the parlor and rooms immediately above. The section through the windows shows, on a small scale, practically the same details as are illustrated in Exercise III, whereas the section through the eaves of the roof and porch illustrate the principles explained in connection with Exercise II. The foundation walls of brick are carried down, and show the footings of concrete or stone.

81. This section is to be drawn as an exercise and it should be built up exactly as the house would be. The grade, or ground line, should be drawn about 2″ above the lower border line, and the footings of the cellar walls should be drawn in place at a scale of $\frac{1}{4}''$ to the foot and about 6′ 0″ below the grade line. These walls, as explained in the plans, are 12″ thick, the footings spreading 20″. The details for the widths of the rooms, locations, and partitions should all be taken from the first- and second-story plans, either by accurate scaling, or by means of a strip of paper laid across the plan on which the thickness of the partitions, the widths of the rooms, and other details are marked to transfer to the sectional drawing. The height of the ceilings and the thickness of the floors should be carefully laid off according to the measurements given for the elevations and figured on the plan section and details. The location of the windows and the heights above the floor should be figured according to the room in which they are situated. From 2′ to 2′ 4″ is a sufficient height for ordinary sitting-room and bedroom windows, although in a nursery it is sometimes advisable to have them higher to prevent accidents. In the kitchen, windows are located as high as 3′

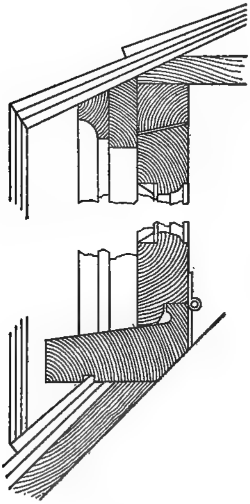


Fig. 61

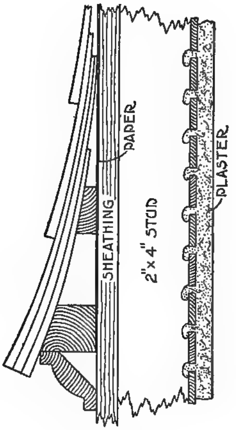
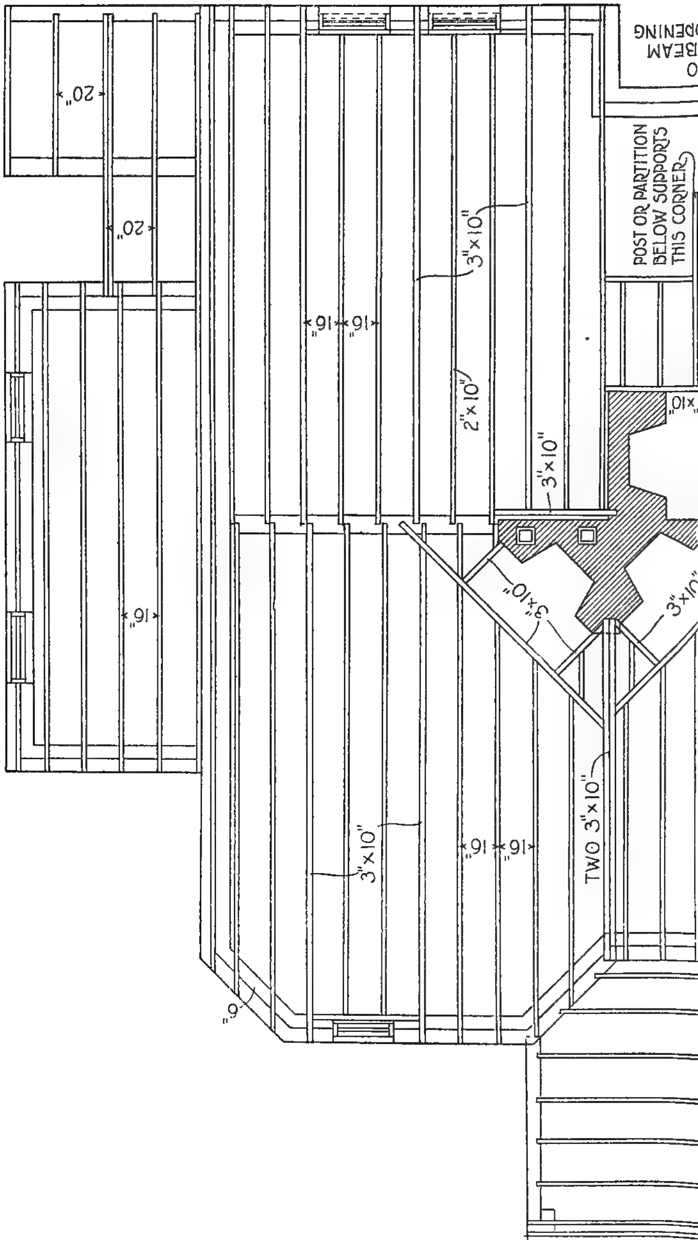
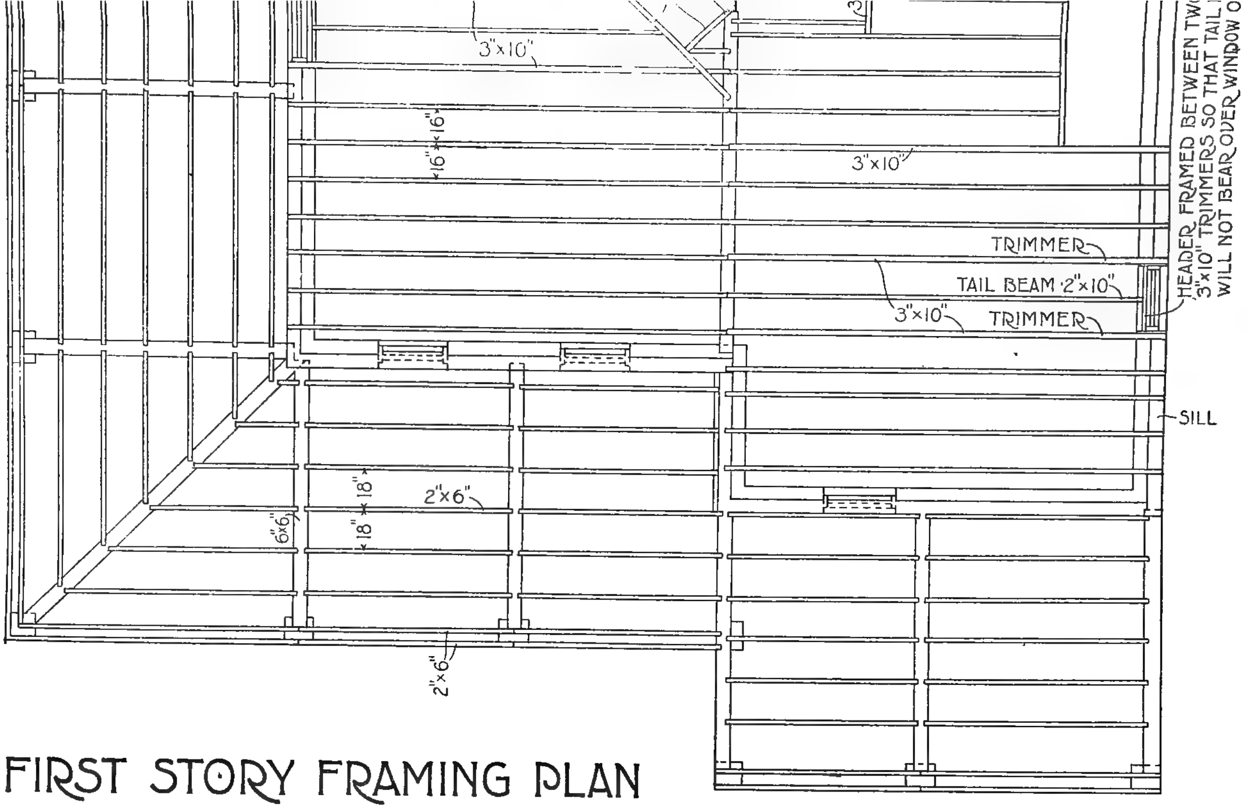


Fig. 62


BEAM
POST OR PARTITION BELOW SUPPORTS THIS CORNER
20"
20"
16"
16"
16"
3"×10"
2"×10"
3"×10"
3"×10"
3"×10"
3"×10"
TWO 3"×10"
3"×10"
16"
16"
6"



FIRST STORY FRAMING PLAN

from the floor in order to permit the kitchen table to stand under them. The windows on the stairs and stair landing can be made any convenient height to present a good appearance, as they are used principally for ventilation.

The doors above the first story are to be five-paneled, but there are many varieties of doors, and the system of paneling depends entirely on the style of architecture and the taste of the designer. The mantels in the parlor and hallway are simple in character, have brick fronts, and the shelves are supported on brackets; the shelf for the parlor mantel is supported by wooden brackets, and that for the one in the hallway is supported by iron brackets, as already illustrated in the larger details. The positions of the stairs, balusters and other details can be taken from the plan. Sections should be properly colored, and the proper data lettered on the sheets, as for former exercises.

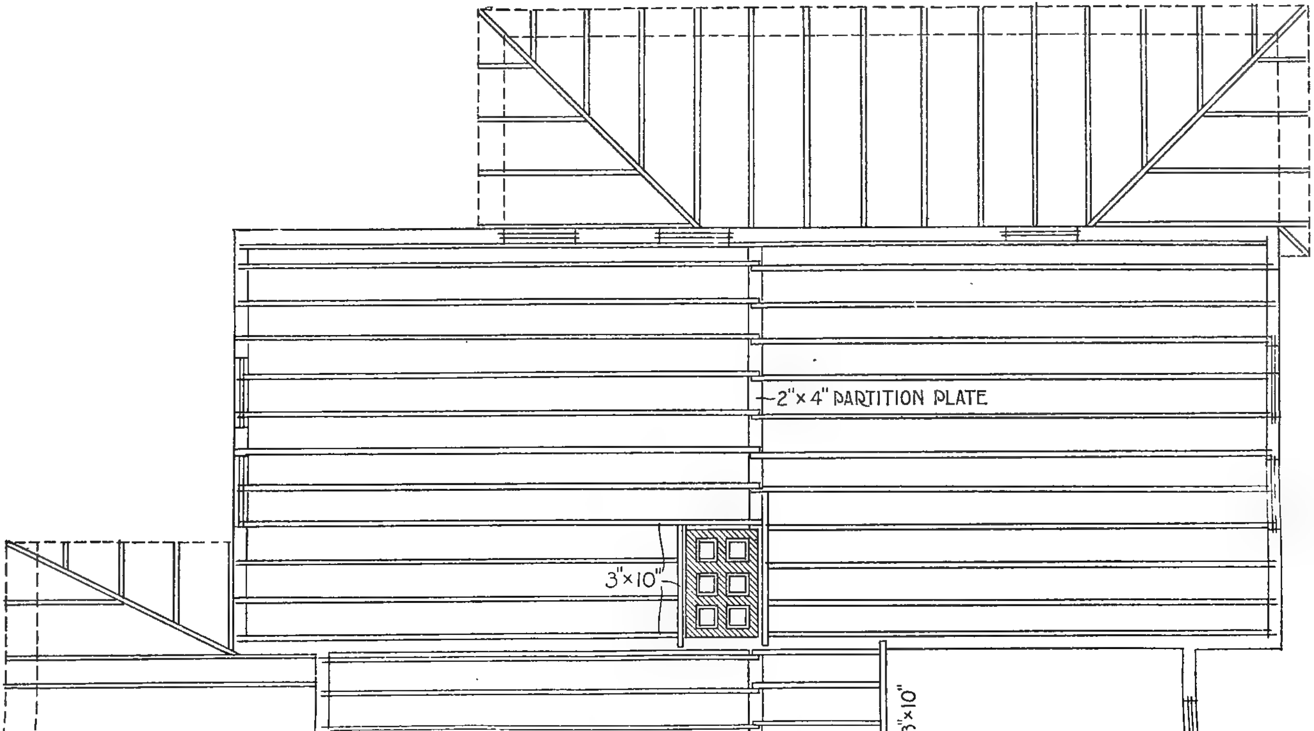
Fig. 61 shows a detail of a section of the roofing over the dormer-window, at the upper right-hand portion of the transverse section. Fig. 62 shows a detailed cross-section of the sheathing and shingle arrangement around the string-course above the first-story windows, as shown at the right hand of the transverse section.

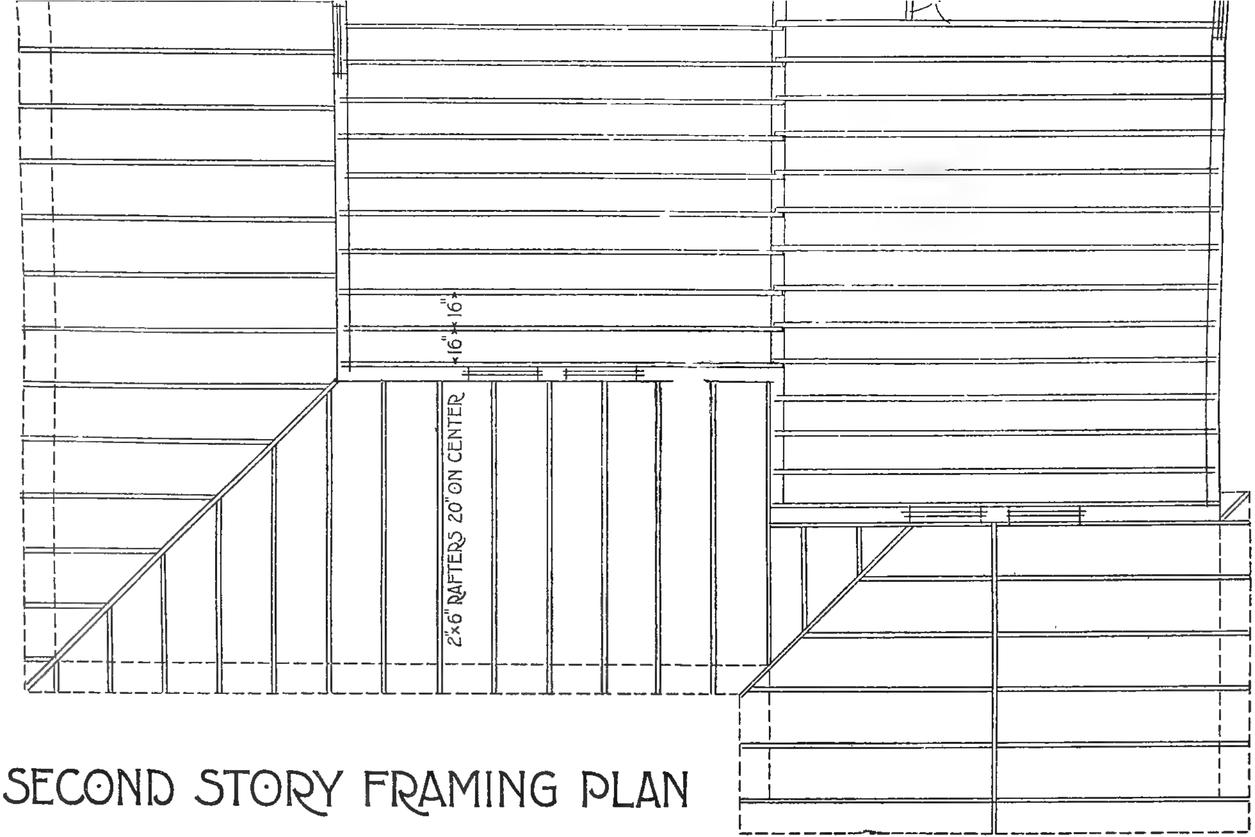
FLOOR FRAMING AND LATHING

82. Floor Framing.—Although the architectural draftsman is not frequently called on to make a diagram showing the position and size of floorbeams in a frame building, it is well that he should consider their general arrangement in order that he may intelligently carry out all the drawings for his plans, elevations, and sections.

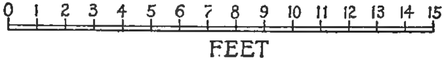
In Fig. 63 is shown the framing diagram of the first-story plan. It will be observed that the walls shown in this plan are the walls of the foundation or cellar, inasmuch as it is on these walls that the beams of the first story rest. Beams extend across the building from the 12″ outside wall to the 6″ × 8″ girder in the center of the house, with auxiliary beams framed around the opening of stairs, chimneys, etc. to carry the framework at this point. Where beams are framed around a fireplace, the supporting members are made heavier in order to carry the additional weight. The girder beam, or short beam, into which the long ones run in order to form the stairway or other opening, is called a *header*, while the other ones projecting into it are known as *tail-beams*. The heavy side beam that carries the header is called a *trimmer*. The outer row of lines across the beams, called *bridging*, consist of diagonal braces nailed between the beams from the bottom of one to the top of the next, in order to thoroughly brace them and prevent them from twisting. The bridging running across the building can be observed by referring to the longitudinal section.

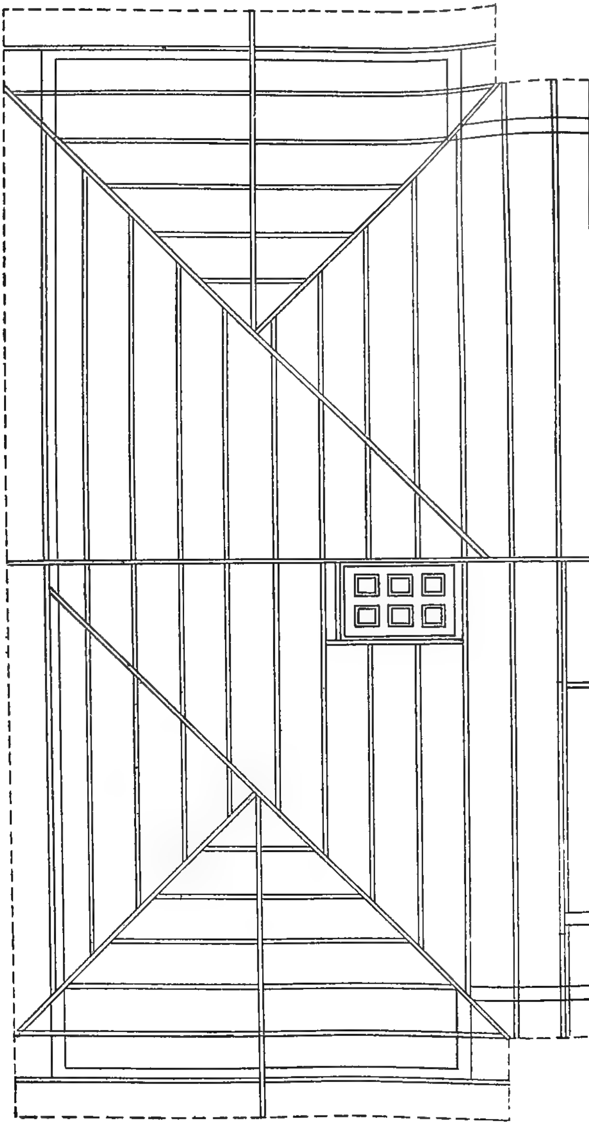
83. In Fig. 64 is shown the second-story plan and the outlines of the first-story wall under it. In the rectangular room above the dining room, it will be observed that the beams are carried out and project beyond the front wall below, thus necessitating the framing of a special plate over the bay window for them to rest on. Under all partitions running parallel with the beams, two regular floorbeams are placed. These are marked 2″ × 10″ in section, and are set 2″ apart, thus making a distance of 6″ across through the upper edges. The studs of the partition rest on these beams, but being only 4″ in width they leave 1″ of beam projecting one ach side. This 1″ projection provides nailing space for the floor boards, which are afterwards put on. Where a partition runs across the floorbeams, a 2″ × 4″ sill is first laid, and then the studs are stood apart. Where the beams of the second story rest on the partition of the story below, a 2″ × 4″ cap is nailed on top of the lower studs and the ends of the beams rest on this. Where the second-story partitions run parallel with the floorbeams, an extra floorbeam is usually inserted the same as the one below, in order to form a nailing surface for the ends of the laths as they reach across from the beam beyond. The method of framing floorbeams around fireplaces, etc. is shown in Fig. 43.

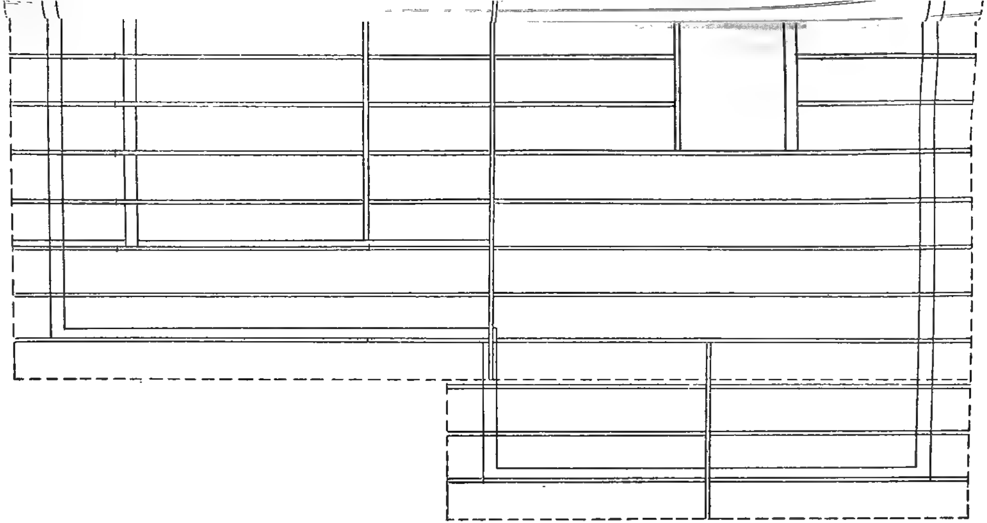

2"x4" PARTITION PLATE
3"x10"
3"x10"



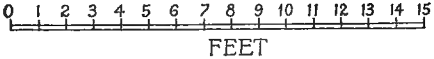
SECOND STORY FRAMING PLAN







ROOF PLAN



84. The roof beams, or rafters, shown in Fig. 65, are usually spaced 20″ on centers unless they are to be ceiled on the under side, in which case they should be set 16″ on centers. A collar beam, or tie, should connect each pair, in order to prevent them from spreading under the weight, unless the floorbeams or ceiling beams serve this purpose. After the roof is complete, it is necessary to treat the apex in some manner that will keep out water. Fig. 66 shows a method where sheet metal is carried over the ridge and serves to form a water-tight drain, and another method is shown in Fig. 67, where a turned wooden roll is laid over the angle.

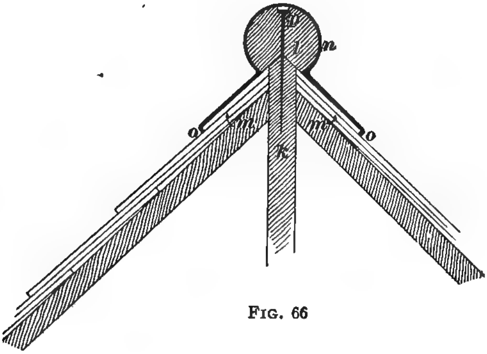


FIG. 66

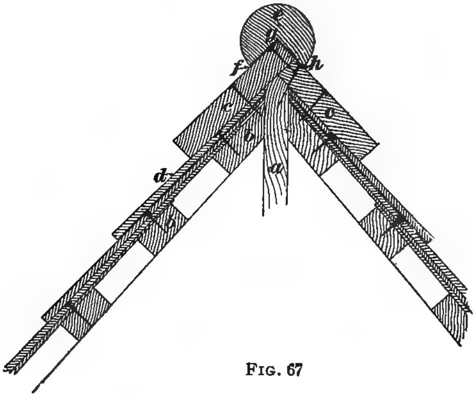


FIG. 67

85. Lathing.—In nearly every case, a wall that is to be plastered requires some form of lathing on which the mortar can be spread. In some cases, the plaster is applied directly on the brickwork, but this is not practical in an outside wall, as moisture will work its way through. Therefore, in plastering on brickwork, it is necessary to use furring strips, as already described. Laths are made of both wood and metal, although the former is more common for ordinary work. Wooden laths are usually about ¾″ at the end and 4′ long, the thickness and width varying in different localities, but the length always remaining the same. Therefore, the studs on which laths are nailed, or the furring strips laid for them on masonry walls, should be spaced either 12″ or 16″ apart in order that their ends may be properly secured. Metal laths are used largely in steel buildings, where they are stretched on small structural-iron framework and plastered over in the usual way. These laths come in several forms—in strips similar to the wooden laths, and also in the form of a cross-wire cloth, or meshwork. In any case, they consist of a series of openings separated by metal strips so that the plaster may be crowded through to form a key on the inner side.

EXERCISE XII, TITLE: SECOND SIDE ELEVATION

86. It is the intention in Exercise XII that the drawing shall be designed and worked out according to personal ideas, and shall include all the details of the side elevation opposite the one that has already been executed under detailed instructions. This elevation will differ materially from the other one inasmuch as there is no veranda on this side of the house, but the arrangement of the windows must be considered in respect to the various levels of stair landings and principal floors, and the dormer-window on the roof will be much wider and differently divided than the one on the opposite side. Besides these varying details, all others must conform in every way to the front and side elevation already drawn. The height of the ridges, the location and projection of the eaves, and the size and position of every detail must correspond identically where it appears on each drawing, and no detailing that has not already been shown on the other elevation is to appear on this elevation. No difficulty should be experienced if the value of each member and the purpose of its introduction are carefully studied.

Complete the drawing carefully, lettering the title, name, class letters and number, date, and time occupied in the work in the usual places.

TRACINGS

87. The completion of four floor plans and three elevations is all that is practically necessary in the way of general drawings for the erection of a house, but a rear elevation showing the details of arrangement should be made if the rear of the house is to face on or is to be seen from an important street. For these exercises, however, it will not be necessary to work out this rear elevation, and the tracings may be proceeded with at once. In tracing the plans and elevations, care should be taken to see that all is very exactly done. The tracing linen is laid over the drawing and fastened in place with thumbtacks, the tracing being made on the dull side of the linen with waterproof ink. In order that the tracing linen may readily take the ink, it is advantageous to sprinkle some powdered chalk on the surface of the cloth and rub it in with a handkerchief or soft rag; a very small quantity of the powder is sufficient. The lines in architectural tracings should be broad and bold, and should possess the same characteristics as the pencil lines in the original drawings.

In this subject the student is required to prepare and send to the Schools for correction FIVE TRACINGS, of the plans and elevations he has completed, as follows: Exercise IV, First-Story Plan; Exercise V, Second-Story Plan; Exercise VI, Cellar Plan; Exercise VII, Front Elevation; Exercise VIII, First Side Elevation.

If the student has not made his tracings, one by one, after the execution of each plate, then, after completing the twelve regular exercises he should prepare the five tracings, according to the method described above, and send them to us all at one time. If they are satisfactory each one will receive a percentage certificate and (if all the preceding work in the subject shall have been completed satisfactorily) a completion certificate will be given on Architectural Drawing.

BLUEPRINTS

88. We require students to submit only the *drawings* of the twelve exercises and the *tracings* of the five exercises mentioned in Art. **87**; no blueprints are required. However, students frequently desire to have directions for making blueprints, and such directions are therefore given below.

The Process.—Blueprinting consists of subjecting to strong sunlight a sheet of prepared paper (blueprint paper) which is covered by the tracing and held in close contact by means of a sheet of heavy glass. The light passing through the transparent tracing causes the "blueprint paper" to turn blue all over its surface except where protected by the opaque lines of the tracing, and thereby produces a print that duplicates the original drawing, but in white lines on a blue ground.

The Blueprint Paper.—While it is not particularly difficult to prepare one's own blueprint paper by sensitizing it with the proper chemical solution (the process of which will be furnished the student if desired) it is far more economical to purchase blueprint paper ready for use. For the sake of economy and that they may secure the best results, students are urged to purchase blueprint paper already prepared for use.

Making the Print.—The printing frame should be large enough to accommodate a sheet 14″ × 18″. The frame is placed face downwards, and the back is removed by unhooking the brass spring clips and lifting it out. The tracing is laid upon the glass with the inked side downwards, touching the glass. A sheet of blueprint paper, perfectly dry, is laid upon the tracing with the yellow (sensitized) side against the tracing. (Do not allow the blueprint paper to be exposed to the light until ready to use it.) The paper and tracing are smoothed out so as to lie perfectly flat upon the glass, and the frame is then closed to hold them securely. The frame, glass side up, is then placed in the sunlight, the time of exposure depending on the paper, conditions of lighting, etc.

Time of Exposure.—A proper exposure will give a print that shows pure white lines on a deep blue background. If the paper comes out a light blue with the lines faint it has not been exposed long enough; if the paper comes out quite dark, and the lines dim or bluish in tint, it has been exposed too long. By testing with a small tracing and a small piece of blueprint paper in this way, and noting the number of minutes required to produce a clear distinct print, the exact time for the exposure of a large print may be determined for various kinds of paper and various conditions of lighting. Some blueprint papers print very rapidly; two or three *seconds* will be long enough, and if printed longer the print will be spoiled. Therefore, preliminary tests must be made for all kinds of papers, as described above, to determine rapidity of printing.

Washing the Print.—The print is then removed from the frame, in subdued light, and (yellow side downwards) is washed in water in a *flat* tray, dish, sink, washtub, or any other convenient receptacle that has a perfectly *flat* bottom, and is moved about to prevent spotting. If many prints are washed the water should be renewed frequently.

Drying the Print.—After washing, the print should then be hung by two adjacent corners by means of "newspaper clips" or pins on a line to dry.

NOTE.—As stated above, these directions for making blueprints are given for the benefit of those students that want to know about the process. There is little need, however, for the student to go to the expense of purchasing a blueprint frame and materials, and taking the time and trouble to make blueprints. There are certain firms that make a specialty of doing blueprinting at a charge of only a few cents per sheet, and the student wanting blueprints made is advised to have it done by these specialists. Names of firms doing such work will be furnished on request.

GENERAL HINTS ON HOUSE PLANNING

89. Arrangement and Sizes of Rooms.—It has been shown that the sizes and proportions of certain constructive details in a house are dependent on commonplace facts. Thus, inside partitions are 6″ thick, because the studs are 4″, and the lath and plaster on each side 1″ thick. Brick walls and piers are more or less dependent on the common sizes of brick. The sizes of windows are influenced to some degree by the commercial sizes of sheets of glass. Thus, a definite reason may be given, within certain limitations, for the general sizes of various structural details.

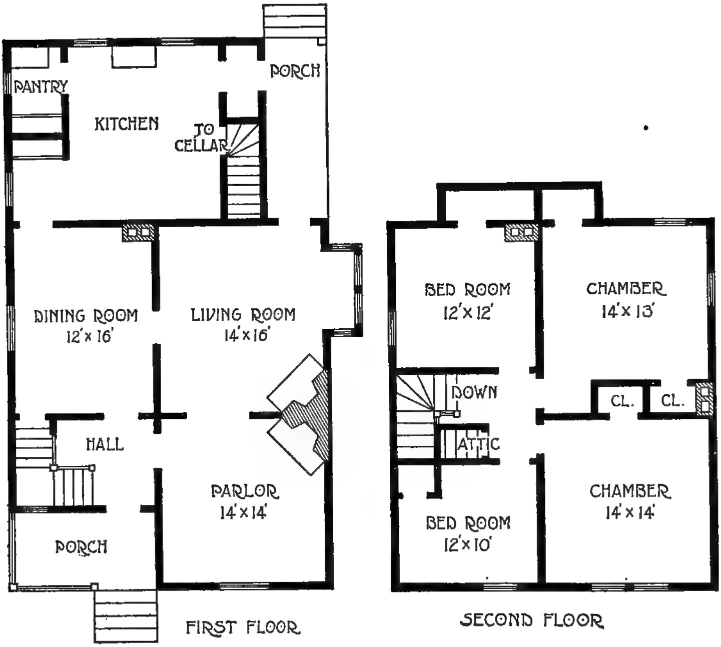


Fig. 68

In like manner the shapes and sizes of the various rooms in a house can be based on commonplace facts or standard sizes of other details and furnishings; that is on fixed unities. It is possible, for example, to make a room of such proportions that, when the carpet is laid, there will be no waste; or, if a rug is desired, that an even border will be left around the rug on the edges. Economies of this nature should not be carried too far, however. Consideration may be given to the condition of a room, so that carpets will not be cut greatly to waste; but the attempt to avoid a small amount of waste is to sacrifice more value in the construction of the house than could be saved in the laying of the floor covers. However, it should be borne in mind that these are details to be considered even if not followed too closely.

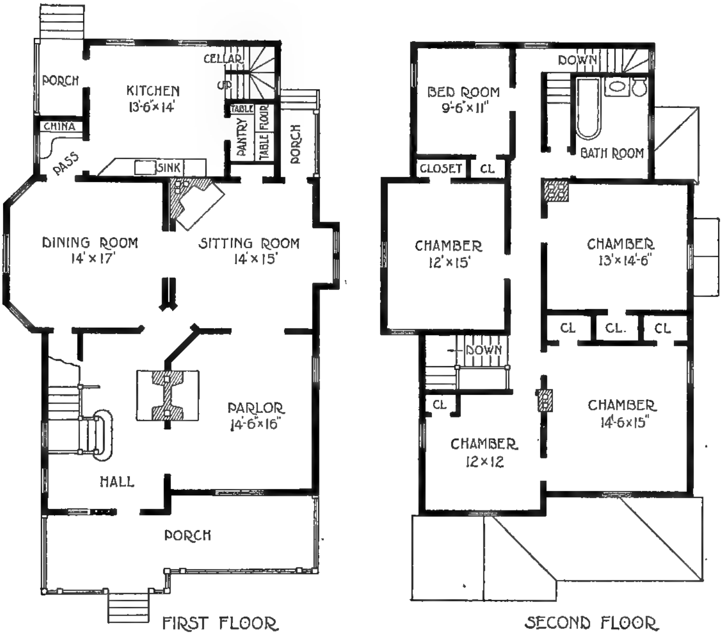


FIG. 69

90. Regardless of the great variety found in the plans and arrangement of houses, it will be observed that they can all be reduced to one general system. In a moderate-priced house, where the rooms are necessarily small, a great similarity of plan exists; but while this similarity of plan

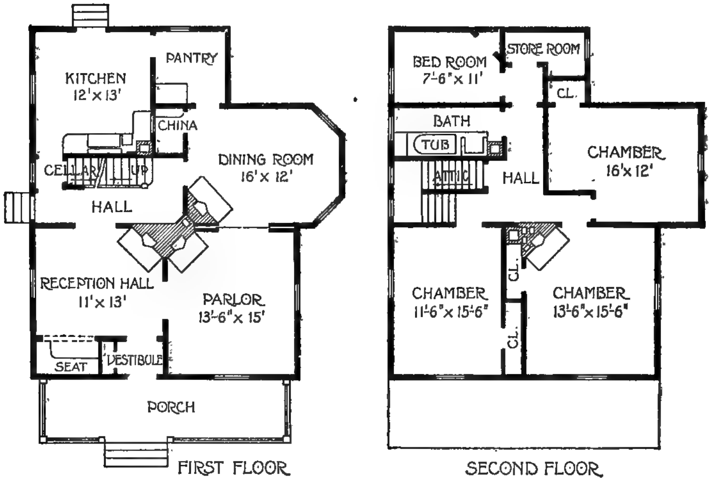


FIG. 70

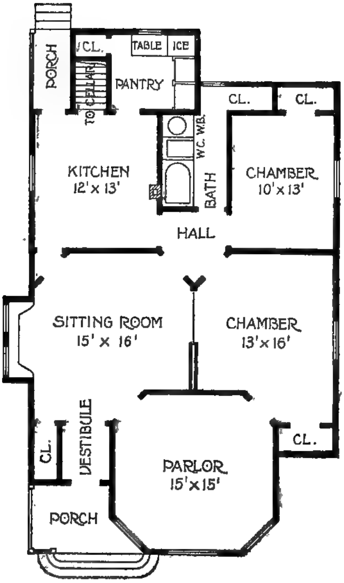


FIG. 71

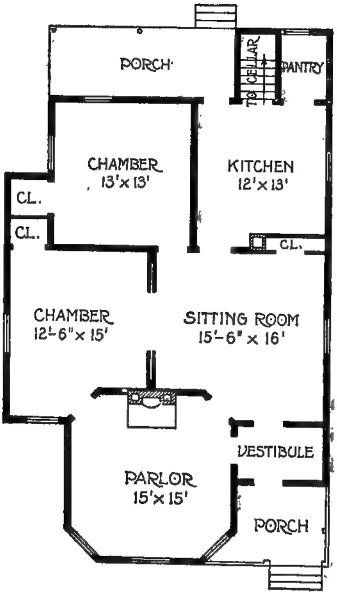


FIG. 72

exists, there can be a great variation of house design and general appearance.

The number of times that the unit plan has been used indicates its popularity; hence, in Fig. 68 is shown a plan where one form or another has been used quite as often as any other arrangement.

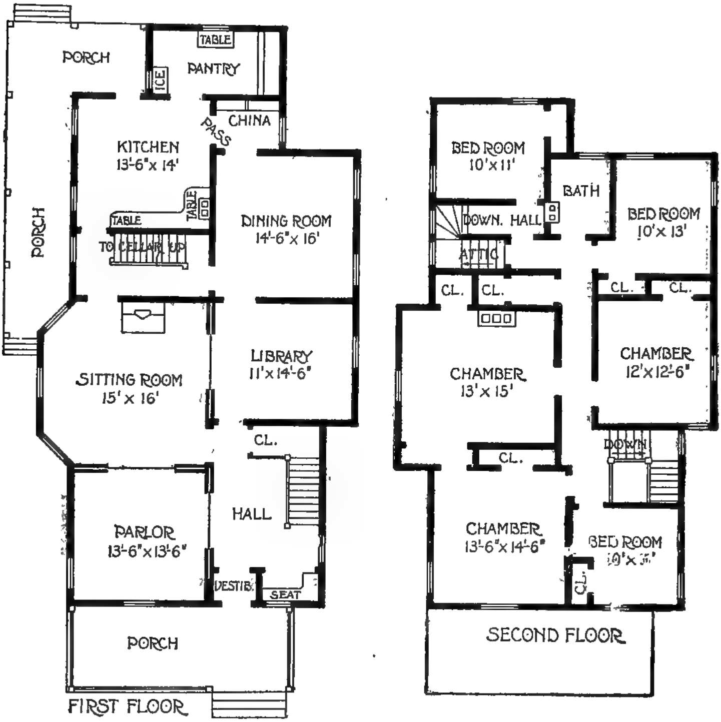


FIG. 73

Fig. 69 is a development of Fig. 68, the change being effected by increasing the size of the hall, rearranging the fireplaces, and extending the kitchen. The general location of the rooms relative to one another is the same, but the house is larger and hence permits the introduction of a bathroom and an extra bedroom in the second story, together with a back stair leading to the kitchen.

In Fig. 70 is the plan of an eight-room house, the relative position of the rooms being practically the same as before. An economical grouping of fireplaces in the first story enables one central chimney to do service for four rooms and possibly the cellar furnace. This house is larger and more expensive than the other two, and serves to show the advantages and greater space obtained by a slight extension. A still cheaper variety of house, frequently used for simple residences and often for mechanics' homes, is the one-story house, which must necessarily have its sleeping rooms on the ground floor.

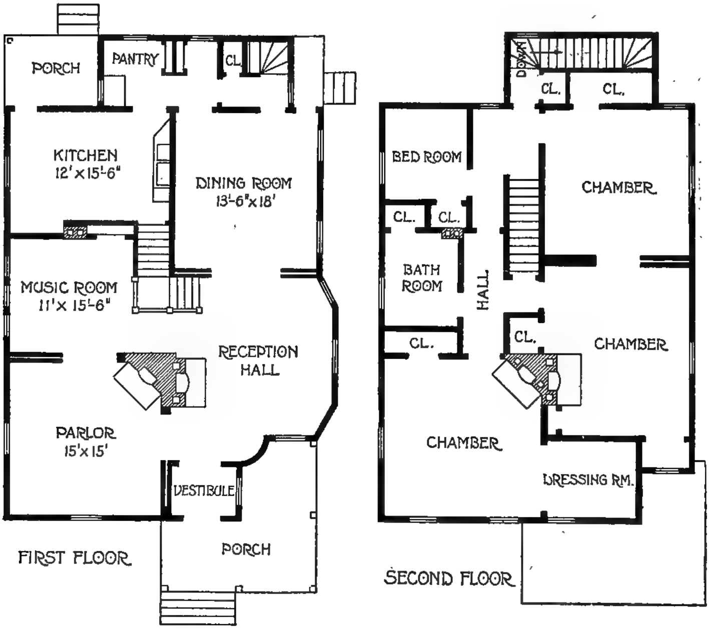


Fig. 74

Fig. 71 shows a cottage with five rooms, bathroom, and pantry; while Fig. 72 is a development of Fig. 71, presenting a house of lower cost owing to the simplification of the details and the omission of the bathroom. Fig. 73 presents a larger and more pretentious plan, with six rooms on the first floor and a side-hall entrance. These bedrooms on the second floor are ample accommodations for a large family, and the house works up well in elevation. In a household where there are children, a side entrance is very advantageous, as they can go in and out of the house without disturbing those in other parts of the house. A similar arrangement is obtained in Fig. 74, for an entrance at the rear by the back stairs enables the children and servants to enter and leave the house without passing through the more formal rooms in front. The position of the stairway in this plan, as well as of that in Fig. 73, permits it to be used both as a service and as a general stair. However, the winding stair at the back supplementing this provides a delightful arrangement for a house of this size.

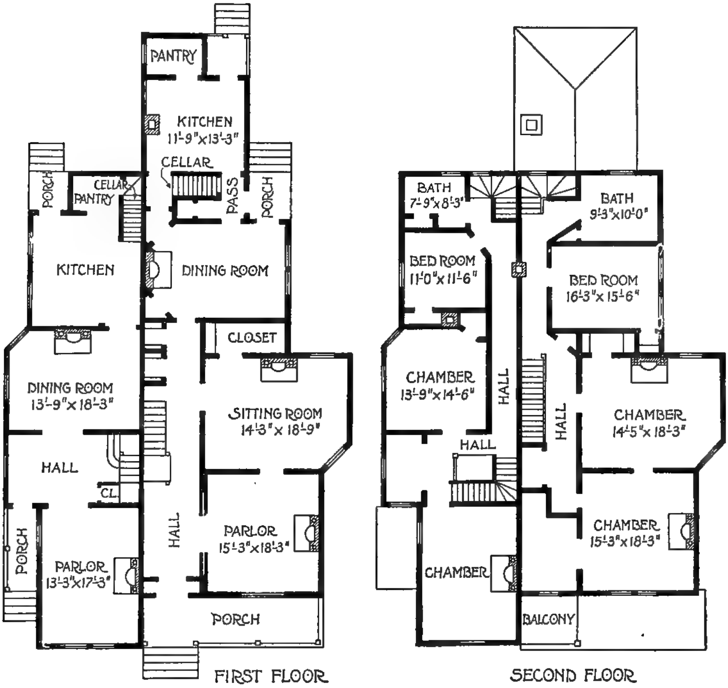


Fig. 75.

91. Double Houses.—Where houses must be crowded into a small space, double houses are frequently necessary. These are not easily planned, as they may have to be long and narrow in order to get them on the lot.

In Fig. 75 is shown a plan for a double house that was built originally for the owner to live on one side while he rented the other. The two entrances are so arranged as to be shut off from each other so that considerable privacy is obtained. The right side of the house is much larger than the other, and the arrangement of the second story is such that with the two halls coming together any noise from the rooms on one side will not likely be heard in those on the other side.

These few plans are given in order that an idea may be formed of general house-plan arrangement. The variations that can be worked on them are infinite, and according to the foregoing suggestions and from these sketches and their modifications, no difficulty should be encountered in drawing plans that will suit the requirements of all ordinary circumstances.

92. Other Buildings.—It has not been the purpose of this Section to train the student to design residences of all styles and costs, or to plan such structures as hotels, apartment houses, theaters, churches, municipal buildings, libraries, etc. The various plans, elevations, details, etc., in this Section have been those of a simple frame residence, for the reason that the principles of planning and construction that apply to such a simple building are the same that underlie the planning and construction of more pretentious buildings, such as churches, hotels, etc. The only new things that must be learned for the proper designing of these larger structures are the peculiar requirements of their uses, their increased sizes and costs, new structural materials, etc.

Further, the beginner as a draftsman or an architect usually makes his start with such simple residence work, and it is only after he has gone some distance in his profession that he can think of attempting to design larger and more costly structures. The ambitious beginner, who is also wise will, however, see the advantage of keeping well stocked with catalogs of the best architectural books, and of reading regularly good architectural magazines, so that he may keep posted as to what is going on in his profession.

THE PRACTICAL APPLICATION

93. The Student's Responsibility.—Experience has shown that it is the tendency of students studying textbooks to assume that the contents of those textbooks are the sum and substance of, and the final word on, all information obtainable. The student must guard against narrowness in this respect, particularly when learning such a practical art as planning and drawing house plans and elevations. He must remember that not all the information to be had is bound up between the covers of his Instruction Paper; there are numerous other sources of information.

The value of reading the most up-to-date books published on all phases of this profession, and the benefits of being a regular subscriber to one or more architectural magazines, have already been pointed out. However, the most fruitful method of obtaining valuable practical information on house planning and house building is to seize every opportunity to watch a house or other building in actual process of construction. There are very few towns or villages, however small, where there do not exist numerous opportunities to observe buildings being erected. In many cases the student need not go out of his way to find them; all he needs to do is to keep his eyes open and observe, and to understand what he sees.

One morning as he passes what he has always known as a vacant lot he sees some men with a surveying instrument taking sights and driving pegs. That is the time he should start to watch what is going on; they are laying out the foundation lines. Soon after that he will see other men making excavations for the cellar; soon the masons will be laying the foundations and putting in the frames for the cellar windows. Then he will soon see the carpenters laying the heavy sills and girders, erecting the studs, etc., etc., and from that time on each day's operations will be well worth watching. His opportunities will increase in value as the operations progress, particularly if he can get on good terms with the local foreman and occasionally get a look at the blueprints.

The location of the house itself as well as each room and each closet, and the reason therefor, may be determined. The method of framing, of sheathing, etc. (if the house be of wood), and the methods of masonry construction (if the house be of stone or brick) may be easily seen. A notebook should be carried, in which pencil sketches and explanatory written notes may be entered regarding points of arrangement or construction. The importance of this personal observation of building operations cannot be emphasized too strongly.

Actual practice over the drawing board is, of course, the only method of making a well-trained draftsman, and of advancing him in his profession. But what the draftsman draws will always be to him nothing more than a meaningless mass of lines and figures, unless he becomes acquainted—by means of up-to-date reading and by personal observation—with actual building arrangements, and with materials and methods of construction.

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